City of Austin
WATERSHED PROTECTION

Supplemental monitoring of selected water bodies with contact recreation impairments.

SR-11-04

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Abstract

Nutrient and indicator bacteria data were collected at seven sites in five Austin creeks that are on the draft 2010 Clean Water Act section 303(d) list of impaired water bodies proposed by the TCEQ. The supplemental data was collected to verify the TCEQ assessment that the creeks are not supporting designated uses of primary contact recreation in the Texas Surface Water Quality Standards due to elevated bacteria levels (30 TAC 307.7(b)(1)(A)(i)). These streams may also be "of concern" under Clean Water Act section 305(b) due to nutrient enrichment. Flow monitoring indicated that Eanes Creek below the Barton Springs Edwards Aquifer recharge zone is ephemeral; therefore, the bacteria impairment for this site is not appropriate according to TCEQ assessment methodology. Bacteria levels are low enough at the Westlake-Davenport Tributary site to fully support primary contact recreation uses. Primary contact recreation is not supported at the Waller Creek, Taylor Slough South or Spicewood Tributary to Shoal Creek sites. Elevated nutrients at Waller Creek appear to be from and indeterminate source of sewage contamination and those at Westlake-Davenport are most likely from nearby residential fertilizer application.

Introduction

The Texas Commission on Environmental Quality (TCEQ) assesses contact recreation safety using fecal indicator bacteria. The currently preferred indicator is *Escherichia coli* (*E. coli*) bacteria. Bacteria data are assessed to determine contact recreation impairments following specific procedures (TCEQ 2010a) in compliance with sections 305(b) and 303(d) of the federal Clean Water Act. Contact recreation impairments are identified when the geometric mean, an estimate of the median of log-normally distributed data or the back-transformed mean of a logarithmically-transformed variable (Sokol and Rohlf 1995), exceeds 126 colonies per 100 mL (equivalent to 126 mpn/dL) for water bodies designated as primary contact recreation use. Impaired water bodies with sufficient data are identified as those not supporting designated contact recreation standards in the statewide Clean Water Act Section 303(d) list.

Impairments can be resolved through several TCEQ methods including recreational use attainability analyses downgrading the designated use; removal of the sources of impairment followed by additional monitoring to verify the success of the mitigation,; approval of a Watershed Protection Plan encompassing all water quality problems in a jurisdiction by the Environmental Protection Agency; or approval by TCEQ of a Total Maximum Daily Load (TMDL) allocation among sources of impairment that can be shown to meet designated uses.

Stream segments on the 303(d) list in the Austin area may not be the most severely impaired segments in the City of Austin (COA) as not all COA data are submitted through the Clean Rivers Program (CRP) for assessment by TCEQ. The CRP maintains strict quality control requirements that result in higher analytical costs. COA balances a need for broader spatial coverage with screening-level programs like the Environmental Integrity Index (EII) against the increased costs of submitting data to the CRP. Because placement on the 303(d) list requires specific action by the TCEQ and affected local entities, this supplemental monitoring program is focused on these specific impaired segments. COA is pursuing additional programs investigating other bacteria problems in segments that are not listed.

The TCEQ and the COA cooperatively monitored seven sites in five water bodies that were identified as not supporting contact recreation on the 303(d) list (**Table 1**) (TCEQ 2010b). All five water bodies were identified on the 303(d) list with a status category of 5b, indicating that a review of the water quality standards for this water body will be conducted before a TMDL is scheduled. This involves the collection of additional data to verify the impairment, and may in the future involve a Recreational Use Attainability Analysis (RUAA) to verify that these water bodies should maintain primary contact recreation use. The COA conducted the field sampling while TCEQ paid for all laboratory analysis.

Table 1. Water bodies identified on the 2010 draft 303(d) list monitored in this project. The 2010 draft 303(d) list was based on an assessment period from 12/01/2001 to 11/30/2008.

Segment	Water Body	# *E. coli* Samples	# Exceeding Standard	Geometric Mean (mpn/dL)
1429B	Eanes*	2	0	27.71
1403K	Taylor	5	3	374.5
1403J**	Spicewood	8	7	541
1403R***	Westlake-Davenport	0	.	.
1429C_01	Waller	14	12	796.7
1429C_02	Waller	14	12	646.4
1429C_03	Waller	13	7	267.6

*1429B-Eanes listing was originally based on older fecal coliform data outside of the 2010 assessment period.
**Spicewood Tributary is shown on 303(d) list to be in the Bull Creek watershed but actually is tributary of Shoal Creek and should be in segment 1429-Town Lake.

***1403R-Westlake-Davenport was not assessed in 2010 because no data was available in the assessment period.

In addition to determining whether these stream segments support contact recreation use, the data obtained from this study may be used to determine possible sources of fecal contamination. The most probable sources of *E. coli* contamination in Austin's urban streams include sewage spills, chronic sewage leaks from municipal wastewater lines, leakage from on-site sewage facilities (OSSF, commonly referred to as septic tanks), uncollected pet waste, untreated latrine sites that develop where indigent communities congregate and areas where fecal material from urban wildlife accumulates. In some cases the source of fecal contamination can be determined by direct observation of the immediate surrounding area. Analysis of nutrients (nitrogen and phosphorus) present at collection sites can provide additional information regarding possible sources of contamination. High levels of ammonia, in combination with

high *E. coli* counts, can occur where untreated sewage is entering the stream from leaking wastewater infrastructure. Elevated concentrations of phosphorous in streams with low total suspended solid concentrations in combination with high *E. coli* counts may also indicate leaking wastewater infrastructure. Although the Austin Water Utility has made major upgrades to the wastewater infrastructure through the Austin Clean Water Program and subsequent efforts, the reality of any urban sewage collection system is that there is always more to be done.

Under aerobic conditions, some ammonia present in raw sewage is converted into nitrite and then nitrate through a process known as nitrification (Droste 1997). Nitrate contamination of surface and ground water may come from several anthropogenic sources. Where fecal contamination from an urban source is suspected, a combination of high *E. coli* counts and high nitrates, in conjunction with low levels of ammonia and ortho-phosphate, may suggest a source of contamination originating from a location some distance from the surface water being evaluated.

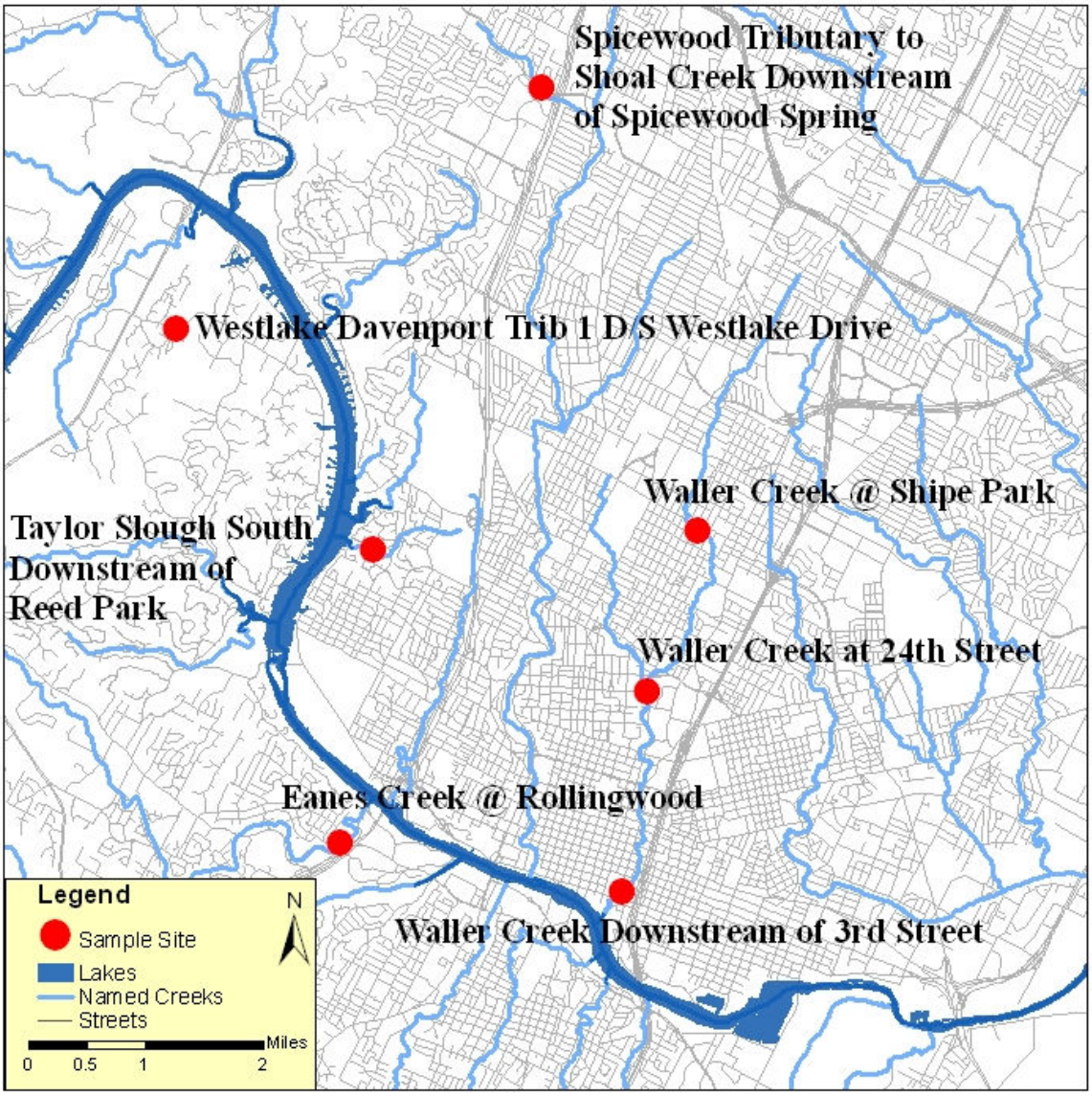
Methods

Site sampling for flow, *E. coli*, ammonia, nitrite plus nitrate as nitrogen, ortho-phosphate and routinely collected surface water field parameters was conducted monthly from April 2008 and continued through August 2010 by COA at 7 sites selected by TCEQ (**Table 2 and Figure 1**). Bacteria and nutrient samples were analyzed at the Lower Colorado River Authority (LCRA) NELAP-accredited lab in Austin, Texas. There were 27 field visits at all sites except Westlake-Davenport Tributary, which was not added to the program until September 2009 yielding a total of 22 field visits. Samples were collected when streams were flowing. TCEQ flow severity was assessed at all sites. Monitoring was ambient, collected when scheduled, rather than targeting specific flow conditions. According to COA definitions (Water Resource Evaluation Section SOP Manual), 2-7 events were performed under probable storm-influenced flow conditions (varied by sample site). Samples were collected following TCEQ Surface Water Quality Monitoring Procedures Manual (TCEQ SWQM Manual, TCEQ 2008). Laboratory analysis was performed according to Clean Rivers Program QAPP requirements. TCEQ paid for all lab analysis.

Table 2. Monitoring sites selected for this project.

TCEQ Site #	COA Site #	Segment	Year First Listed	COA Site Name
15964	182	1429B	1999	Eanes Creek @ Rollingwood
17294	890	1403K	2002	Taylor Slough South Below Reed Park
16316	930	1403J**	2002	Spicewood Tributary Below Spicewood Spring
16310	298	1403R	2006	Westlake-Davenport Trib 1 D/S Westlake Dr
16331	781	1429C_03	2004	Waller Creek @ Shipe Park
15962	4349	1429C_02	2004	Waller Creek @ 24th Street
12222	485	1429C_01	2004	Waller Creek Below 3rd Street

Figure 1. Locations of monitoring sites for this project.



Study Site # 182: Eanes Creek at Rollingwood Drive

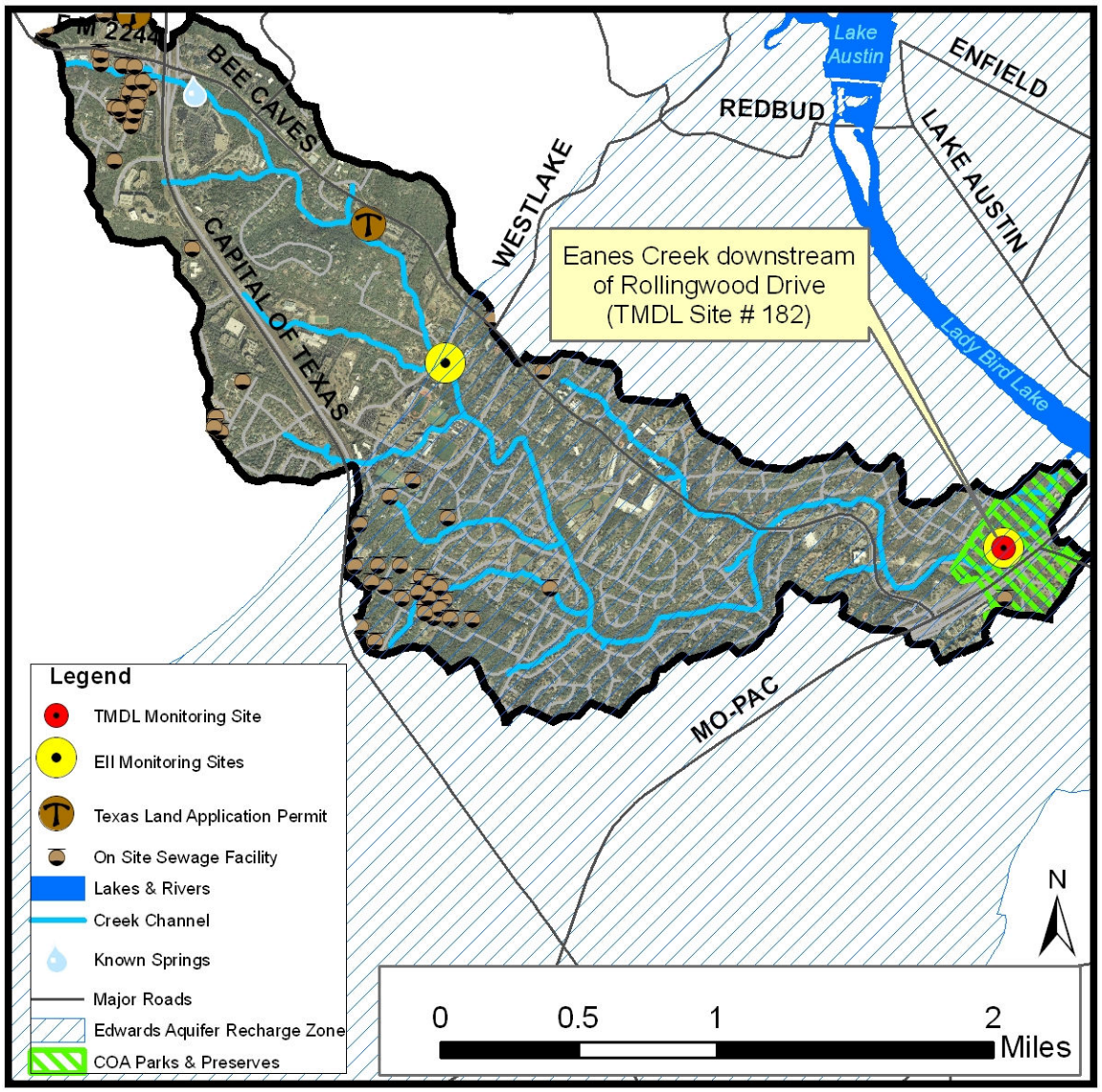
Wastewater collection systems in the Eanes Creek Watershed (**Figures 2-5**) are serviced in part by Austin Water Utility, in part by Travis County Water Control and Improvement District # 10 and in part by the Lost Creek Municipal Utility District. There is one Texas Land Application Permit (TLAP) facility using spray irrigation disposal for treated wastewater upstream, above the recharge zone, and numerous on site sewage facilities (OSSF) are present along the southern and western boundaries of the watershed (**Figure 5**). A single OSSF located approximately 950 ft south of the study site is believed to be abandoned according to COA records. The lower portion of Eanes Creek within the Edwards Aquifer recharge zone boundary is believed to flow only in immediate response to storm events. COA site #182 is located within a COA nature preserve. COA Site #182 was removed from the COA Environmental Integrity Index sampling program subsequent to 2001 due to a lack of flow (Clamann 2008, 2011). Some isolated pools may persist at this location during cool wet weather, but the stream channel within this reach is otherwise dry for most of the year (**Figures 2-4**).

Figure 2. Eanes Creek downstream of Rollingwood Drive, April 8, 2009 (dry)

Figure 3. Eanes Creek downstream of Rollingwood Drive, August 12, 2009 (dry)

Figure 4. Eanes Creek downstream of Rollingwood Drive, December 9, 2009 (some rain pools, no flow)

Figure 5. The Eanes Creek Watershed.



Study Site # 930: Spicewood Tributary to Shoal Creek downstream of Spicewood Spring

The wastewater collection system in the Shoal Creek watershed (**Figures 6-11**) is operated by the Austin Water Utility. A single on-site sewage facility (OSSF) is operating in the upper portion of the watershed. Eleven other OSSF are located in the watershed but are believed to be abandoned according to COA records. One abandoned OSSF is located within the Spicewood Tributary drainage area approximately 3400 feet upstream of the TMDL monitoring site (**Figure 11**). Wastewater gravity collector pipes run down the length of the Spicewood Tributary, with manholes in the stream both upstream and downstream of Ceberry Drive at the immediate sample collection location (**Figures 7-8**). The Spicewood Tributary is heavily influenced by Spicewood Springs Road, stormwater runoff from other adjacent neighborhood streets (pavement chip-seal has been observed in the creek), and may also be influenced by adjacent single-family residences that abut the creek (**Figures 9-10**).

There is a documented small population of the threatened Jollyville Plateau salamander, *Eurycea tonkawae*, at the Spicewood Spring discharge point, which is within the Spicewood Tributary monitoring location. This population has been in a state of decline (Bendik 2009, 2010). In addition to Spicewood Spring, which discharges into the monitoring site, there is at least one additional unnamed spring entering this tributary approximately 500 feet upstream of the sample site (**Figure 11**).

Figure 6. Spicewood Tributary to Shoal Creek downstream of Ceberry Drive, April 8, 2009

Figure 7. Sewer manhole in stream channel upstream of Ceberry Drive Bridge, August 12, 2009

Figure 8. Sewer manhole in stream channel downstream of Ceberry Drive Bridge, August 12, 2009

Environmental Integrity Index data collected from Shoal Creek during 2009 indicated that levels for nutrients were generally within normal range compared to other Austin creeks (some increases seen downstream), but that *E. coli* counts were chronically high relative to other watersheds (**Table 3**). Strontium isotope analysis of the spring discharge is underway, and may be useful in source water identification at this location.

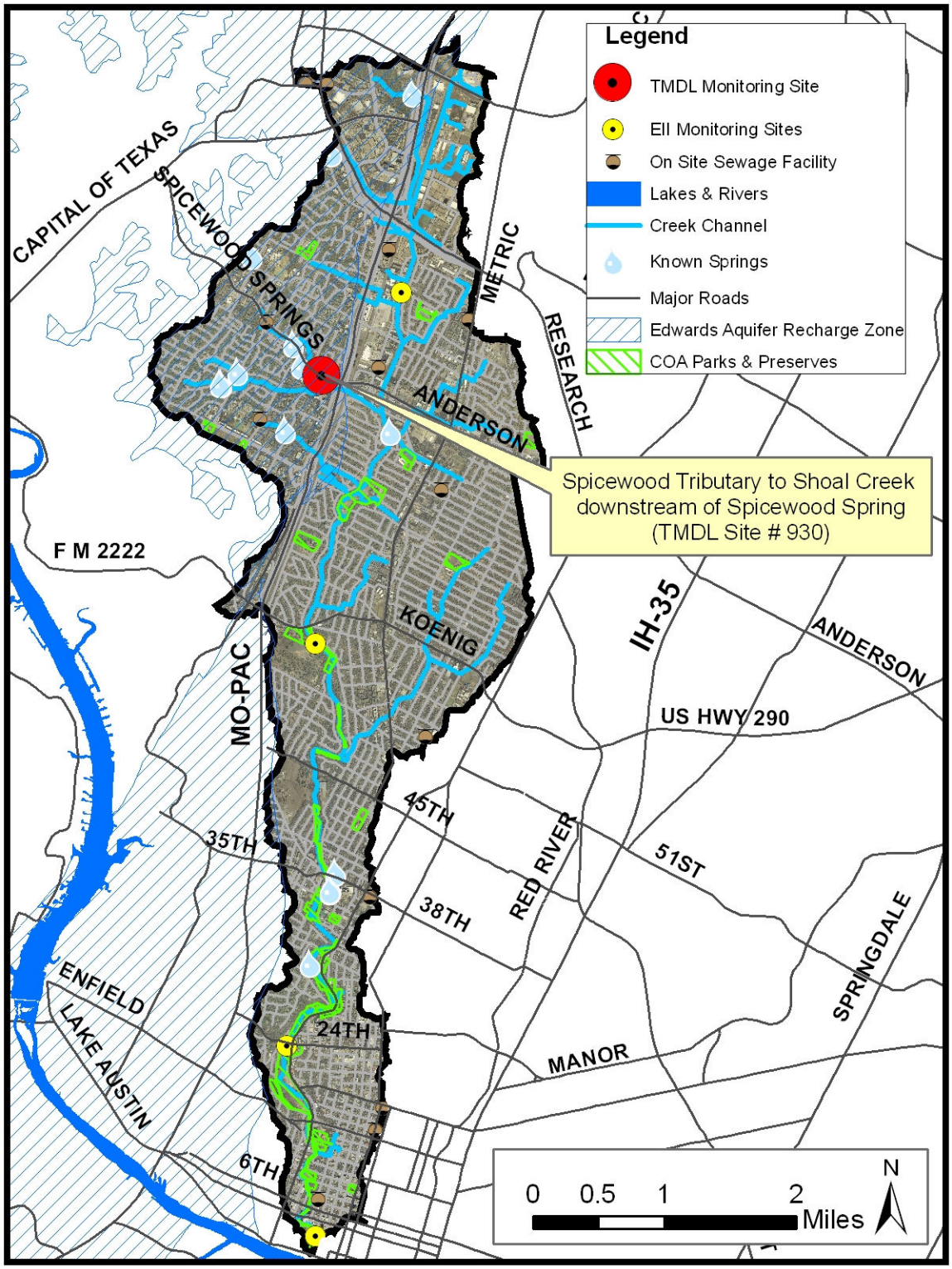
Figure 9. Storm drain emptying into Spicewood Tributary, August 12, 2009

Figure 10. Housing adjacent to Spicewood Tributary, April 8, 2009

Table 3. Summary of EII Nutrient and Bacteria Data Recorded for Shoal Creek During 2009 (Clamann 2011).

Parameter	Mean	Max	Min
Ammonia (mg/L)	0.01	0.026	0.005
Nitrite / Nitrate (mg/ L)	0.36	1.22	0.004
Ortho-Phosphate	0.06	0.2	0.02
E. coli / 100 mL	995	2420	91

Figure 11. The Shoal Creek Watershed, including the Spicewood Tributary, which flows through study site # 930.



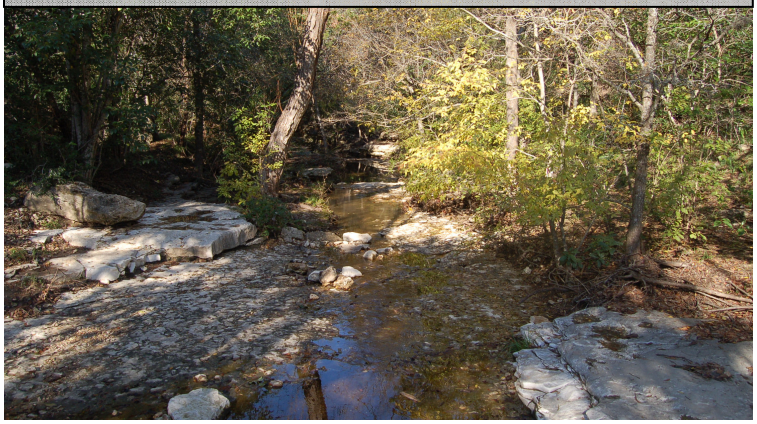
Study Site # 890: Taylor Slough South downstream of Reed Park

The wastewater collection system in the Taylor Slough South watershed (**Figures 12-18**) is maintained by the Austin Water Utility, and multiple wastewater gravity collector pipes parallel and cross the creek immediately upstream of the monitoring location. Some wastewater collectors are shown to be abandoned in the COA database.

TMDL study site # 890 is immediately downstream of Reed Park, a COA park that operates a swimming pool during the summer months and that also maintains restroom facilities. In addition to the monitoring location, there is an EII monitoring site (# 318) within Reed Park approximately 830 feet upstream of TMDL monitoring site # 890 (**Figure 18**). A spring enters the stream approximately 1680 feet upstream of TMDL site # 890 (F**igure 18**). Some sections of Taylor Slough South, which lies entirely within the Edwards Aquifer recharge zone, can become dry during part of the year (**see Figures 14-17**).

Figure 12. Taylor Slough South, downstream of Reed Park (site # 890 – With Flow), looking upstream, December 9, 2009

Figure 13. Taylor Slough South, downstream of Reed Park (site # 890 – With Flow), looking downstream, December 9,



Environmental Integrity Index data collected from Taylor Slough South during 2010 indicated that levels for ammonia and ortho-phosphate were generally within the normal range of that recorded from other Austin watersheds, though some elevated levels of ammonia were reported in 2007 (**Table 4**). EII values for both *E. coli* and nitrite / nitrate samples collected from Taylor Slough South indicated that these two parameters were chronically elevated compared to other Austin watersheds (**Table 4**).

Table 4. Summary of EII Nutrient and Bacteria Data Recorded for Taylor Slough South During 2010 (Clamann 2011).

Parameter	Mean	Max	Min
Ammonia (mg/L)	0.01	0.01	0.01
Nitrite / Nitrate (mg/ L)	2.92	3.88	2.19
Ortho-Phosphate	0.03	0.03	0.03
E. coli / 100 mL	1464	2420	770

Figure 14. Taylor Slough South, downstream of Reed Park (TMDL site # 890 - DRY), looking upstream, April 8, 2009

Figure 15. Taylor Slough South, downstream of Reed Park (TMDL site # 890 - DRY), looking downstream, April 8, 2009

Figure 16. Taylor Slough South, upstream of Reed Park (EII site # 318 – With Flow), looking upstream, April 8, 2009

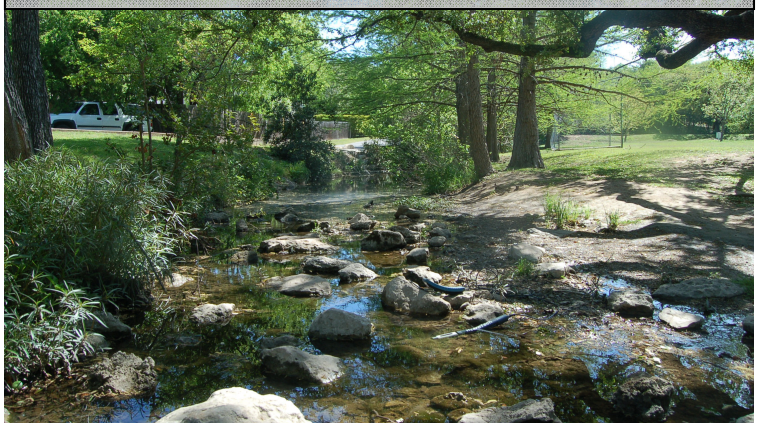
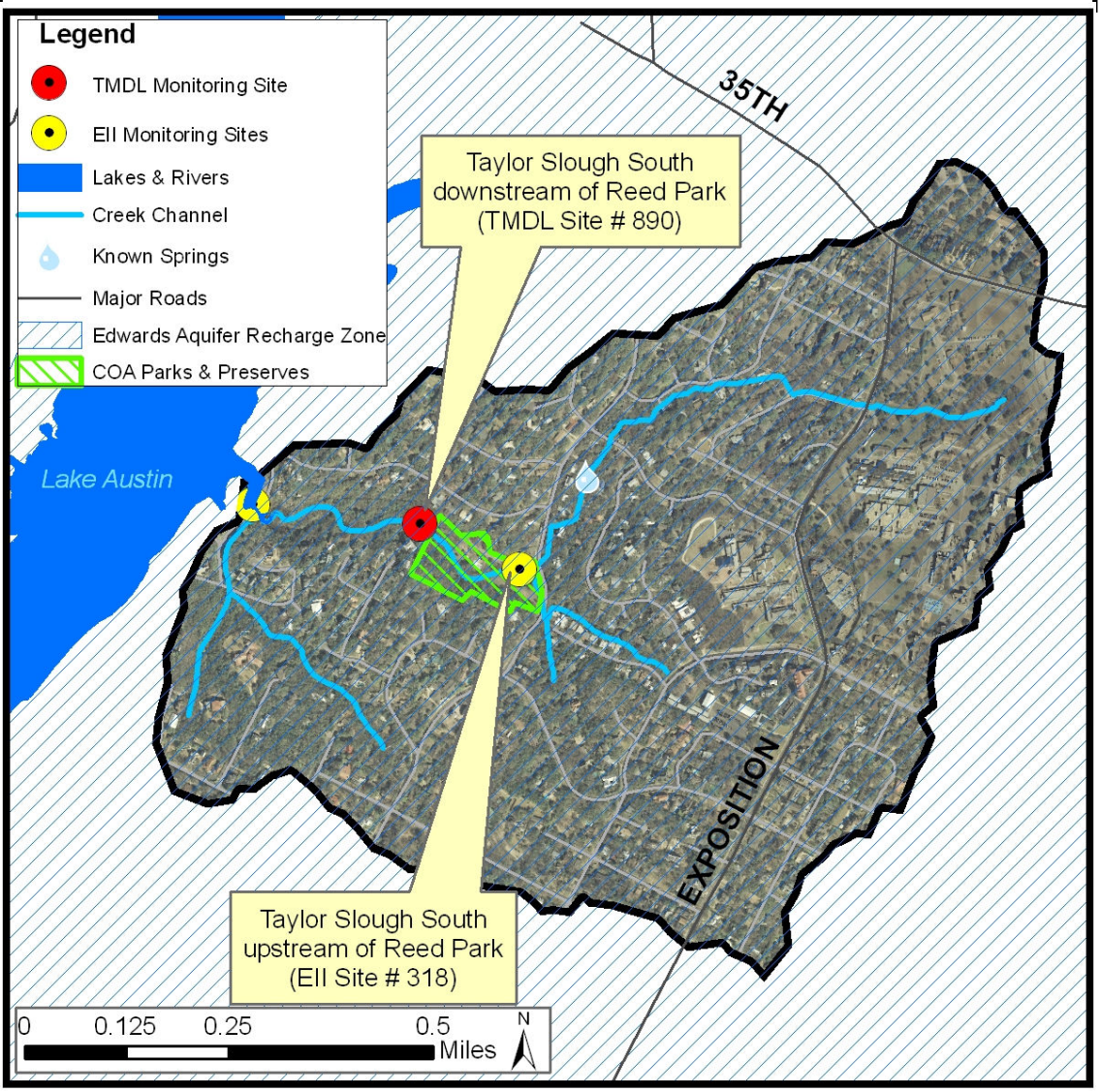


Figure 17. Taylor Slough South, upstream of Reed Park (EII site # 318 – With Flow), looking downstream, April 8, 2009

Figure 18. The Taylor Slough South Watershed.



Study Site #'s 781, 4349 & 485: Waller Creek

The wastewater collection system in the Waller Creek watershed (**Figures 19-28**) is maintained by the Austin Water Utility and wastewater collector pipes run the length of Waller Creek with many direct creek crossings. The COA spatial database shows three abandoned OSSF present within this watershed, but no operating ones in the drainage area (**Figure 28**).

The three TMDL monitoring sites within the Waller Creek watershed are mapped in **Figure 28**. TMDL monitoring site # 781, Waller Creek at Shipe Park, is within a park and residential neighborhood, near the intersection of 45 St and Avenue G (**Figures 19-21**). COA PARD operates a swimming pool at this location, and water from the pool flows into the stream on a regular basis during the summer months (**Figure 21**). TMDL monitoring site # 4349, Waller Creek at 24th Street, is on the campus of the University of Texas at Austin (**Figures 22-24**). Site # 4349 is also approximately 250 feet downstream of the confluence of Hemphill Creek with Waller Creek. TMDL monitoring site # 485, Waller Creek downstream of 3rd Street, is strongly influenced by runoff from the immediate downtown area, aging infrastructure, and may also be affected by the indigent population living in downtown Austin (**Figures 25-27**).

Environmental Integrity Index data collected from Waller Creek during 2009 indicated that levels for ammonia and nitrite / nitrate were chronically above average, but not high, compared to other Austin watersheds (**Table 5**). EII values for ortho-phosphate were generally within the normal range of values recorded for other streams (**Table 5**). EII values for *E. coli* samples collected from Waller Creek were chronically high compared to other Austin watersheds in 2009 (**Table 5**).

Figure 19. Waller Creek at Shipe Park (site # 781), looking upstream, December 9, 2009

Figure 20. Waller Creek at Shipe Park (site # 781), looking downstream, December 9, 2009

Figure 21. Storm drain emptying pool discharge into Waller Creek at Shipe Park (site # 781), August 12, 2009

Figure 22. Waller Creek at 24th Street (site # 4349), facing upstream, April 8, 2009

Figure 23. Waller Creek at 24th Street (site # 4349), facing downstream, April 8, 2009

Figure 24. Waller Creek at 24th Street (site # 4349), right bank showing small dam, April 8, 2009

Figure 25. Waller Creek downstream of 3rd Street (site # 485), facing upstream, April 8, 2009

Figure 26. Waller Creek downstream of 3rd Street (site # 485), facing downstream, April 8, 2009

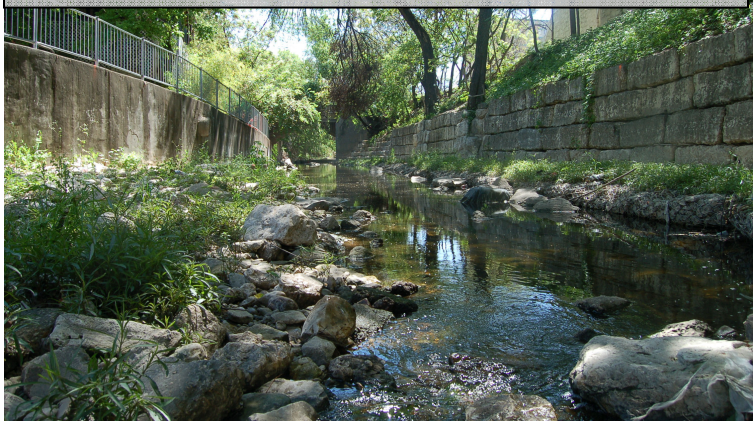
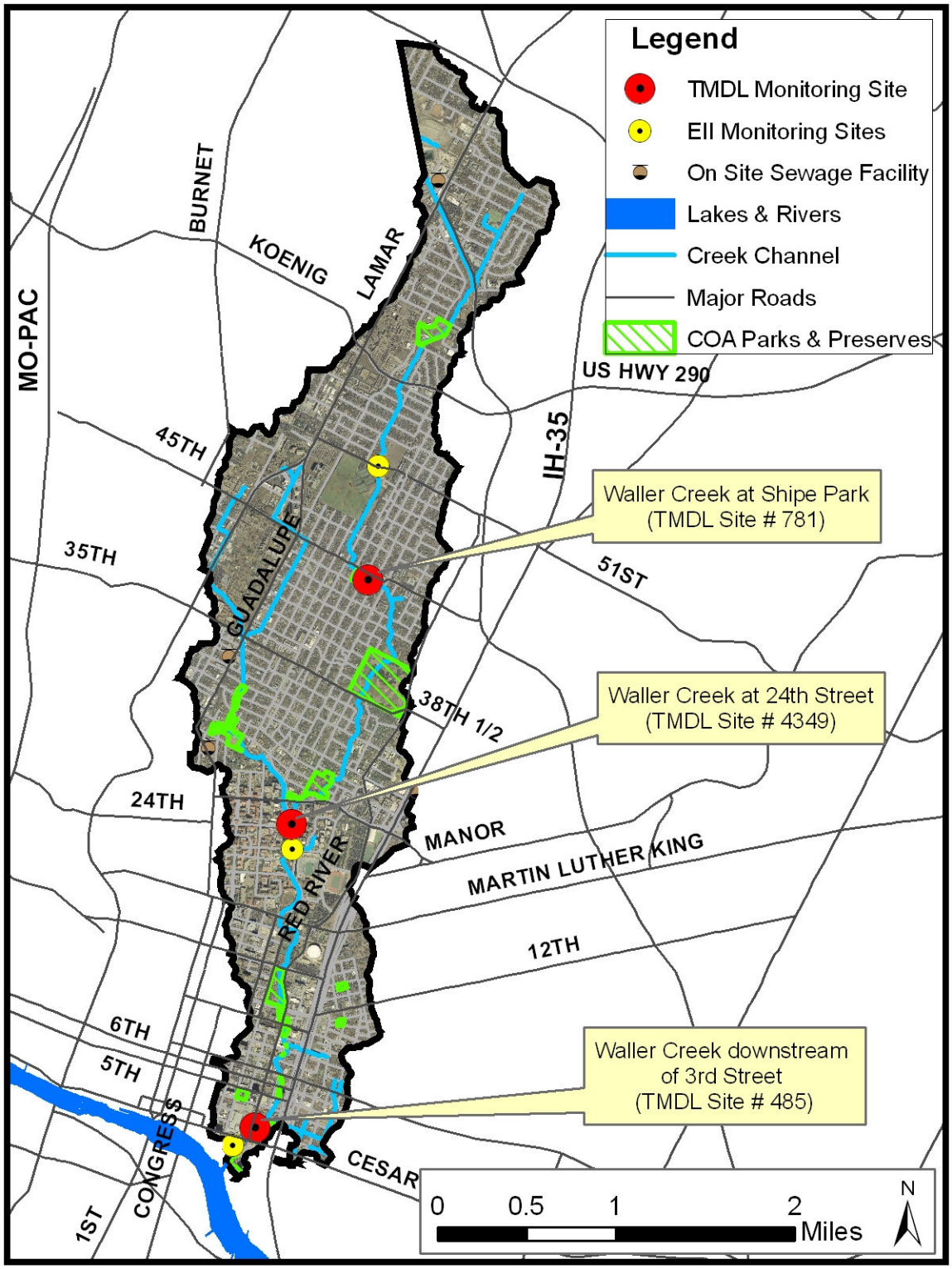


Figure 27. Waller Creek below Red River Street Bridge (site # 485), indigent camp site in background, December 9, 2009

Table 5. Summary of EII Nutrient and Bacteria Data Recorded for Waller Creek During 2009 (Clamann 2011).

Parameter	Mean	Max	Min
Ammonia (mg/L)	0.02	0.08	0.005
Nitrite / Nitrate (mg/ L)	0.43	1.15	0
Ortho-Phosphate	0.11	0.22	0.02
E. coli / 100 mL	1291	2420	230

Figure 28. The Waller Creek Watershed.



Study Site # 298: Westlake-Davenport Tributary 1 downstream of Westlake Drive

Part of the wastewater collection system in the Westlake-Davenport (unnamed tributary to Lake Austin) watershed (**Figures 29-33**) is maintained by the Austin Water Utility and the remainder by Travis County Water Control and Improvement District # 10. Several OSSF are located in the downstream section of the watershed, but none appear upstream within the drainage area of Tributary 1, upstream of TMDL monitoring site # 298 (**Figure 33**). A Texas Land Application Permit (TLAP # WQ0012363001) effluent irrigation permit was issued in this watershed for the Davenport MUD, and the Austin Country Club Golf Course irrigated its grounds with treated effluent for years. However; wastewater has since been diverted to Austin Water Utility system with the decommissioning of the Davenport treatment plant in August of 2009. There is an 8" PVC gravity flow wastewater line and a lift station at the crossing of Westlake-Davenport Tributary 1 and Westlake Drive, approximately 250 feet upstream of TMDL sample site # 298.

Figure 29. Westlake-Davenport Tributary 1 (Site # 298), looking upstream, April, 2009

Figure 30. Westlake-Davenport Tributary 1 (Site # 298), looking downstream, April, 2009

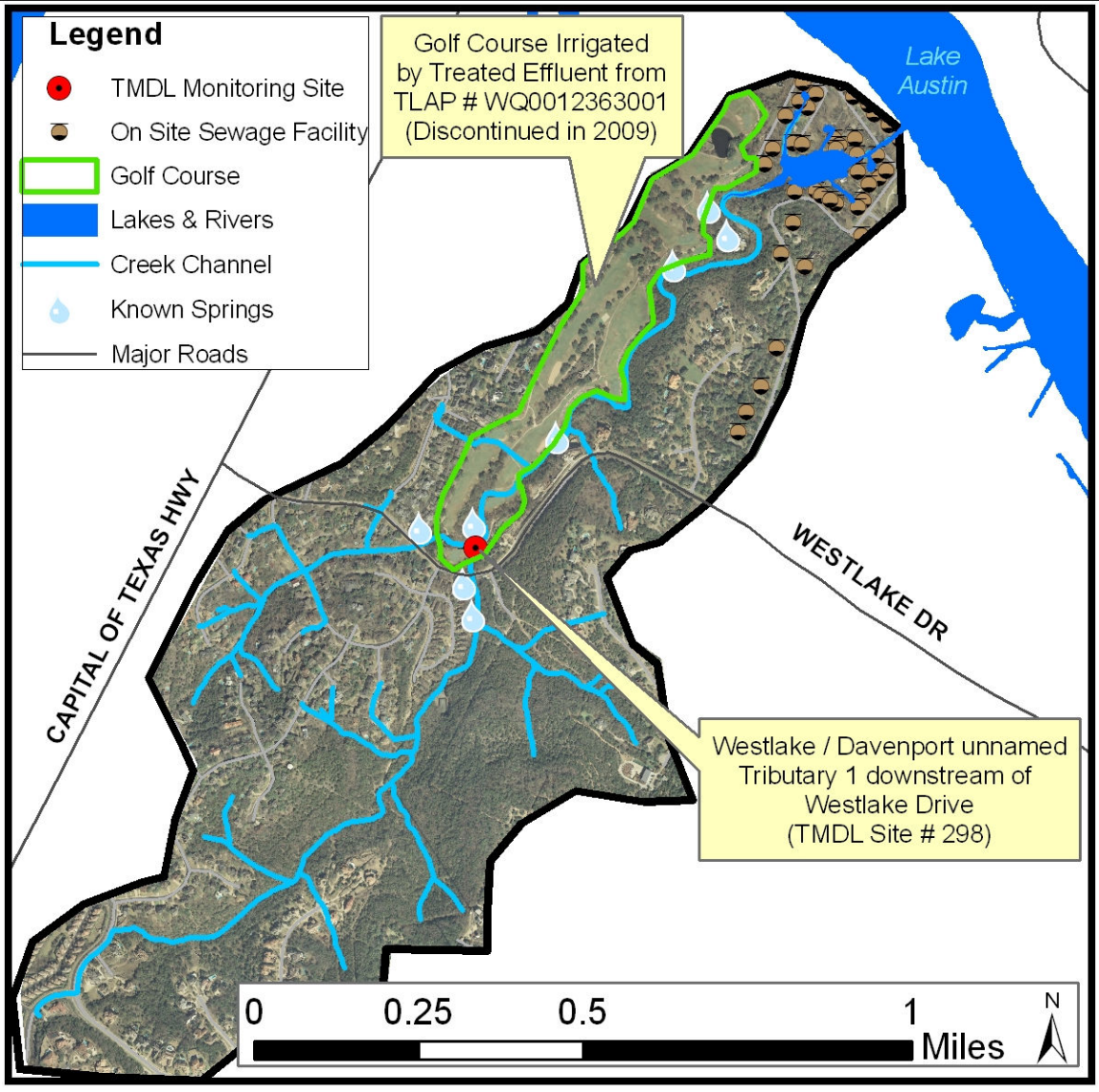
Figure 31. Westlake-Davenport Tributary 1 (Site # 298), left bank near confluence with Tributary 2, April, 2009

The immediate location of site # 298 is downstream of Westlake Drive and within the grounds of the Austin Country Club Golf Course. Management practices at the golf course strongly influence the stream at this location. Mowing occurs down to the stream channel in many areas and vigorous growth of vegetation within the channel may be the result of excess loading of nutrients from fertilizers (**Figures 29-32**).

There are no EII sites located within the Westlake-Davenport watershed and this stream is not currently monitored by that program.

Figure 32. Westlake-Davenport Tributary 1 (Site # 298), golf course along left bank being sprayed, April, 2009

Figure 33. The watershed outline for the unnamed tributary to Lake Austin referred to here as "Westlake-Davenport," including "Tributary 1."



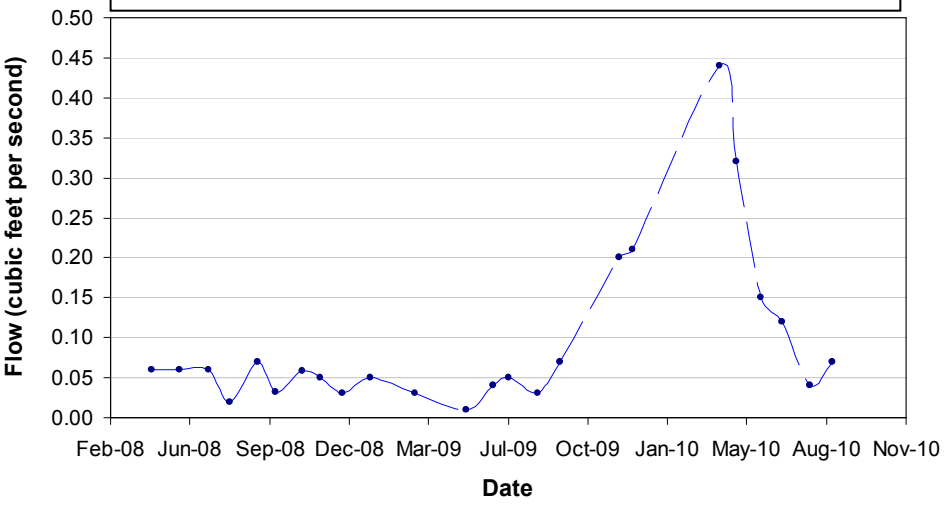
Results for Site # 182: Eanes Creek at Rollingwood Drive

Of the 27 monitoring events at Eanes Creek at Rollingwood, 9 field visits (33%) found Eanes Creek to have pooled water but no visible surface flow between pools and 18 field visits (66%) found Eanes Creek to be completely dry. These site visits confirmed previous observations indicating that the lower portion of Eanes Creek within the Edwards Aquifer recharge zone boundary flows only in immediate response to storm events. Therefore, we concluded that historical indicator bacteria indicator counts that resulted in the impairment listing are likely to have been based entirely upon samples collected during storm flow conditions. On this basis, the 303(d) listing is not supported as data are most likely biased to only storm flow and primary contact recreation use is not indicated. Using the sampling protocol for this study, no water quality samples were collected at Eanes Creek, and the Eanes Creek site is not considered further in this analysis.

Results for Site # 930: Spicewood Tributary to Shoal Creek downstream of Spicewood Spring

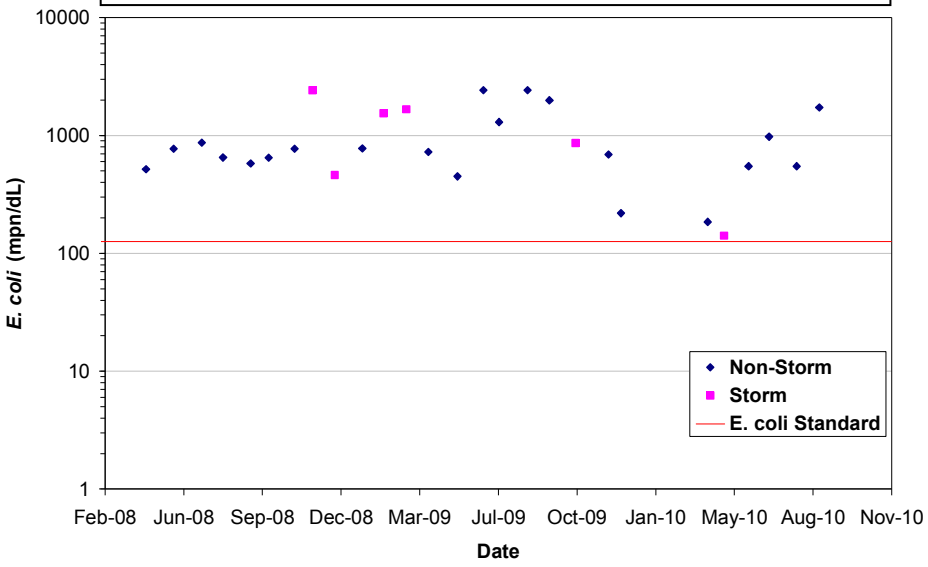
The Spicewood Tributary downstream of Ceberry Drive maintains perennial flow (**Figure 34**), and water samples were collected during each of the 27 monitoring events.

Figure 34. Stream discharge recorded at the Spicewood Tributary to Shoal Creek downstream of Ceyberry Drive (COA site # 930)



The geometric mean of *E. coli* samples collected under both storm and non-storm flow conditions at the Spicewood Tributary downstream of Spicewood Spring was 780 mpn/100 mL, which clearly exceeds the TCEQ contact recreation limit of 126 mpn/100 mL (**Figure 35**). The geometric mean of *E. coli* samples collected at site # 930 under only baseflow conditions was 764 mpn/100 mL and was higher than the geometric means for *E. coli* samples collected at 95% of all EII sites.

Figure 35. *E. coli* samples collected at the Spicewood Tributary to Shoal Creek downstream of Ceyberry Drive (COA site # 930)



The mean for ammonia concentrations in samples collected under baseflow conditions at site # 930 was 0.015 mg/L, and ranked lower than the means for ammonia concentrations recorded at 85% of all EII sites (**Figure 36**). The mean for nitrite / nitrate concentrations in samples collected under baseflow conditions at site # 930 was 2.67 mg/L, and ranked higher than the means for nitrite / nitrate concentrations recorded at 94% of all EII sites (**Figure 37**). This value also exceeded the TCEQ (2010a) screening level of 1.95 mg/L for nitrate (**Figure 37**). The mean for ortho-phosphate concentrations in samples collected under baseflow conditions at site # 930 was 0.018 mg/L, and ranked lower than the means for ortho-phosphate concentrations recorded at 95% of all EII sites (**Figure 38**).

Field notes indicate that the surface water at site # 930 was usually clear during sampling visits. On March 11th, 2009 the water was turbid and dark due to a recent storm event. This storm event coincided with peak values for all nutrients except for nitrite / nitrate, which was much lower on this date. Odors reported in the field notes suggest a slight fouling odor could be detected on several site visits, however; it was not clear whether the odor was the result of sewage, decomposition of organic debris, or of nearby restaurants on Spicewood Springs Road. On April 19th, 2010 there was an odor of dead animals and chlorine present. Litter items in the form of yard waste and cups and containers were occasionally observed at this site, but only rarely.

Recreational uses were not observed during site visits. Access at this location is limited due to the fact private homes abut the creek on the left bank and Spicewood Springs road is adjacent to the right bank. However; there are several parks downstream of this location, the first of which is Beverly Scheffield Park, approximately 1.2 miles downstream on Shoal Creek (**Figure 11**). Primary contact recreation is presumed to occur in these parks unless it can be demonstrated to be absent according to TCEQ criteria.

Figure 36. Ammonia samples collected at the Spicewood Tributary to Shoal Creek downstream of Ceyberry Drive (COA site # 930)

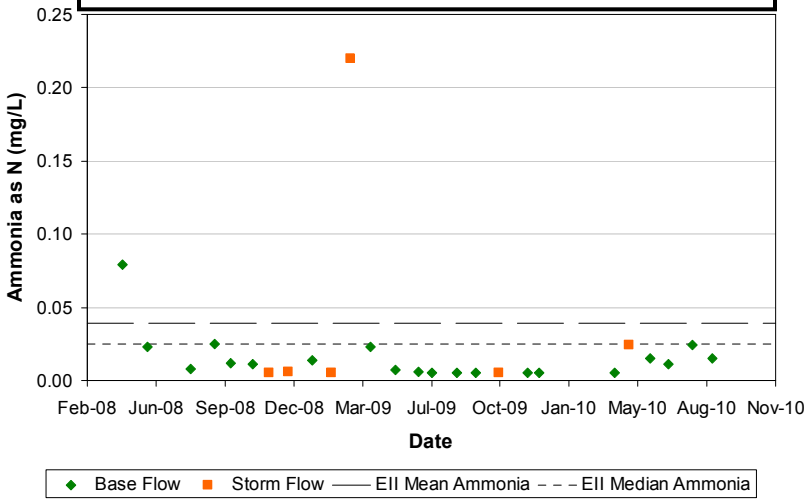


Figure 37. Nitrite / Nitrate samples collected at the Spicewood Tributary to Shoal Creek downstream of Ceyberry Drive (COA site # 930)

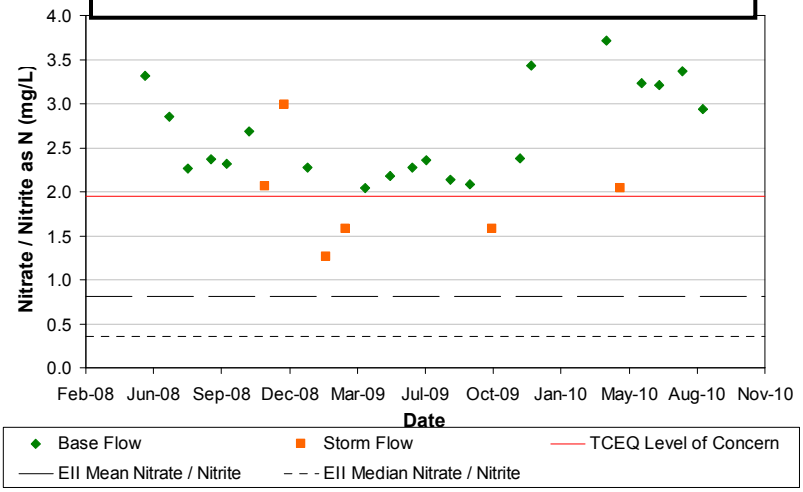
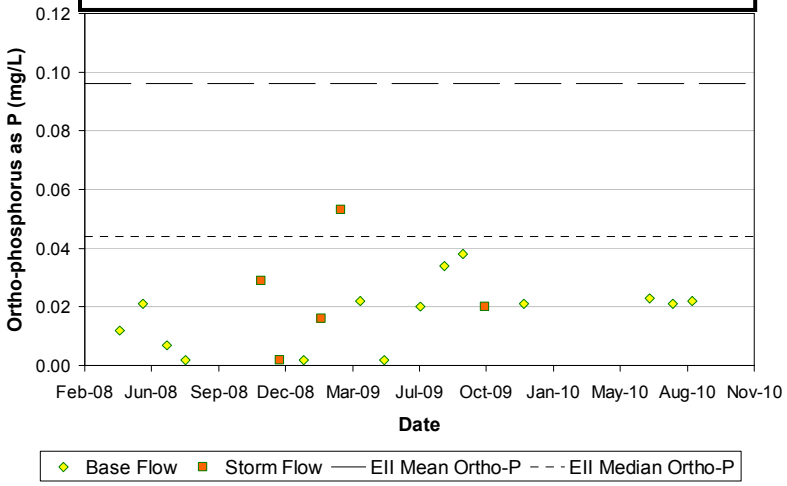


Figure 38. Ortho-phosphate samples collected at the Spicewood Tributary to Shoal Creek downstream of Ceyberry Drive (COA site # 930)



Results for Site # 890: Taylor Slough South downstream of Reed Park

Taylor Slough South became dry downstream of Reed Park at TMDL site # 890 for several months during the monitoring period, but continued to flow within the park and upstream of the park pool area at EII site # 318 during most site visits (**Figure 39, see also Figures 12-17 under Study Sites**). Discharge at TMDL site # 890 occurred with enough frequency to obtain sufficient samples for analysis (n = 12);however; any future monitoring in this portion of the watershed may need to take into account that flows may become reduced or cease downstream of Reed Park.

Figure 39. Stream discharge recorded at Taylor Slough South downstream of Reed Park (COA site # 890, circles), and at EII site # 318 upstream of Reed Park at the footbridge (triangles)

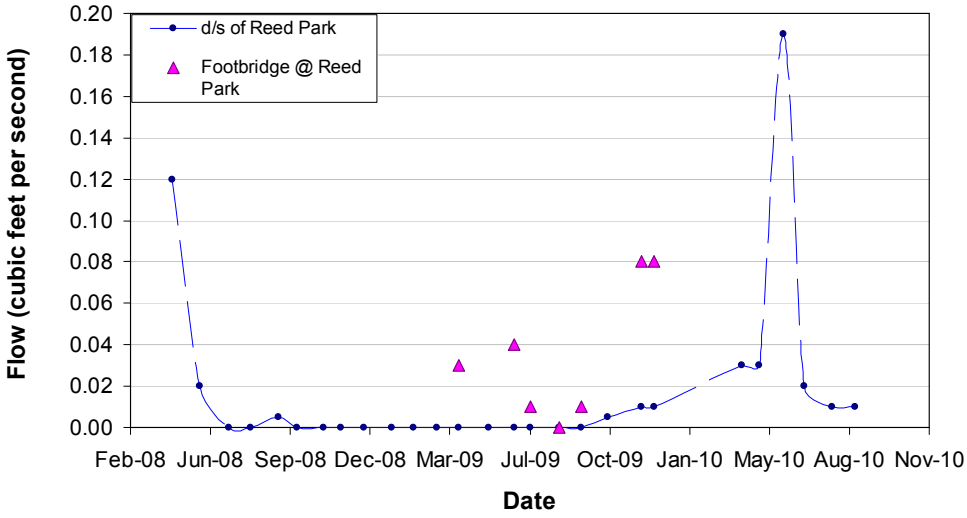
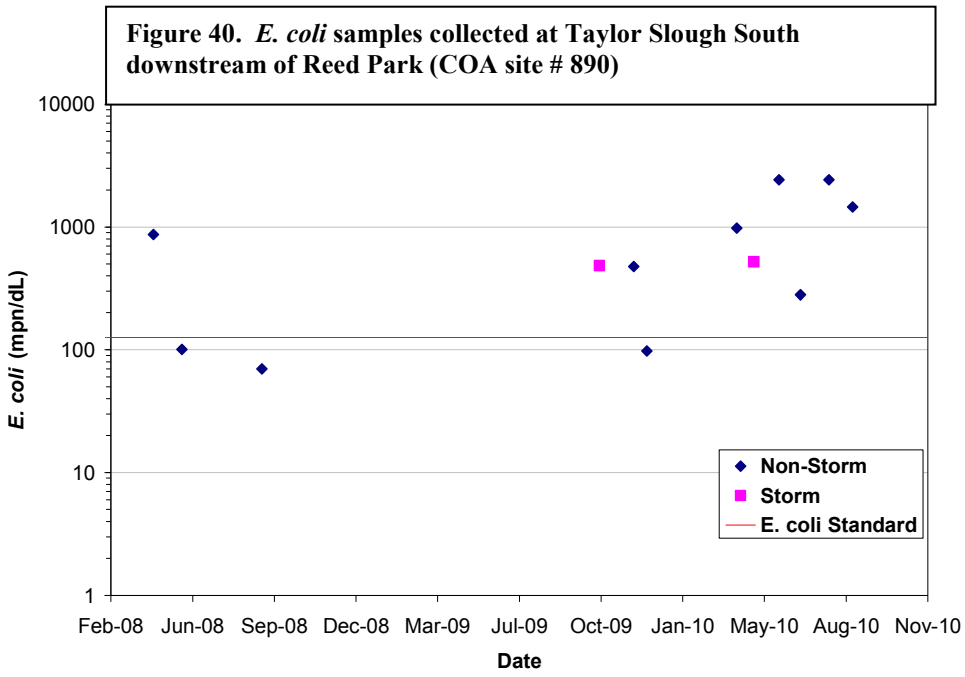


Figure 40. *E. coli* samples collected at Taylor Slough South downstream of Reed Park (COA site # 890)



The geometric mean of *E. coli* samples collected under both storm and non-storm flow conditions at Taylor Slough South downstream of Reed Park was 485 mpn/100 mL, which exceeds the TCEQ contact recreation limit of 126 mpn/100 mL (**Figure 40**). The geometric mean of *E. coli* samples collected at site # 890 under only baseflow conditions was 481 mpn/100 mL, and was higher than the geometric means for *E. coli* samples collected at 89% of all EII sites. There was a gap in the monitoring of TMDL site # 890 due to cessation of flow during part of the sampling period. An additional *E. coli* sample was collected during this period from EII Site # 318 on July 27th, 2009 to evaluate whether the bacteria problem persisted within the stream when the selected monitoring site was dry. The sample value for that date was 517 mpn/100 mL, which is close to the geometric mean reported for the monitoring site.

The mean for ammonia concentrations in samples collected under baseflow conditions at site # 890 was 0.030 mg/L, and ranked higher than the means for ammonia concentrations recorded at 61% of all EII sites (**Figure 41**). The mean for nitrite / nitrate concentrations in samples collected under baseflow conditions at site # 890 was 1.82 mg/L, and ranked higher than the means for nitrite / nitrate concentrations recorded at 90% of all EII sites (**Figure 42**). The mean for ortho-phosphate concentrations in samples collected under baseflow conditions at site # 890 was 0.015 mg/L, and ranked lower than the means for ortho-phosphate concentrations recorded at 97% of all EII sites (**Figure 43**).

Field notes indicate that the surface water at site # 890 was usually clear during sampling events not influenced by storm events. Occasionally a blue or grey color was noted at this site. Field notes for most site visits reported no significant odors present, however; the odor of pet feces and urine was occasionally recorded. Park visitors often had pets with them and in one instance a dog was observed urinating in the creek. On June 17th, 2009 a slight odor of chlorine was reported, and it was also observed that some water was flowing from a pipe that drains the pool area. Evidence of some bleaching of substrate, possibly due to chlorine, was observed on a few visits during the summer months.

The proximity of the pool and park promote accessibility within this reach of Taylor Slough South. Children were observed wading waist deep in the stream on November 23rd, 2009, and others were observed in close proximity to the water on other dates. This site appears to be utilized at times for primary contact recreation.

Figure 41. Ammonia samples collected at Taylor Slough South downstream of Reed Park (COA site # 890)

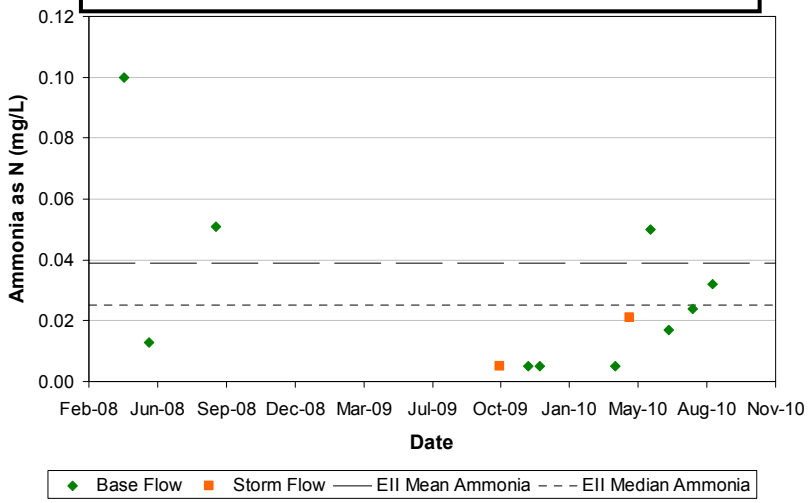


Figure 42. Nitrite / Nitrate samples collected at Taylor Slough South downstream of Reed Park (COA site # 890)

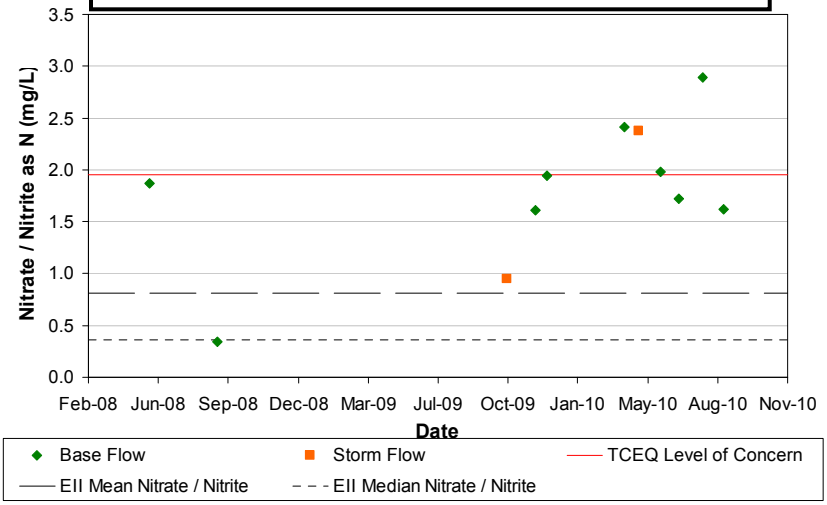
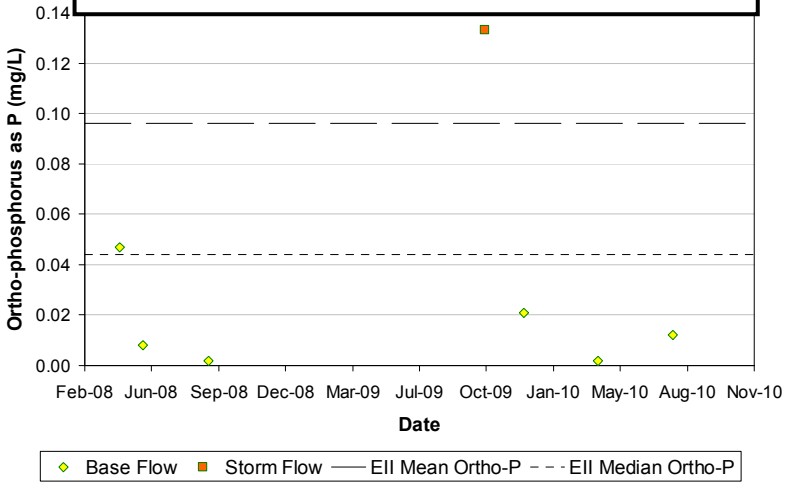


Figure 43. Ortho-phosphate samples collected at Taylor Slough South downstream of Reed Park (COA site # 890)



Results for Site # 781: Waller Creek at Shipe Park

Waller Creek exhibited an unusual flow pattern at Shipe Park. Discharge peaked during the hottest, driest months of the year (June through the end of August), but was low (< 0.02 ft^3/s) during the remainder of the year from September through May (**Figure 44**). It appeared that most of the water flowing in Waller Creek at Shipe Park during the summer months was coming from the Shipe Park swimming pool, which routinely released water through a storm drain immediately upstream of the monitoring site (**see Study Sites Figure 21**). This was confirmed by taking flow measurements at the storm pipe during summer of 2009 (**Figure 44**). At that time flow from the storm drain appeared to represent at least 80-90% of the flow within the stream. Samples were collected on 25 out of 27 field visits, when the stream was flowing.

Figure 44. Stream discharge recorded at Waller Creek at Shipe Park (COA site #781). Discharge from a storm pipe draining to the creek is also shown (triangles).

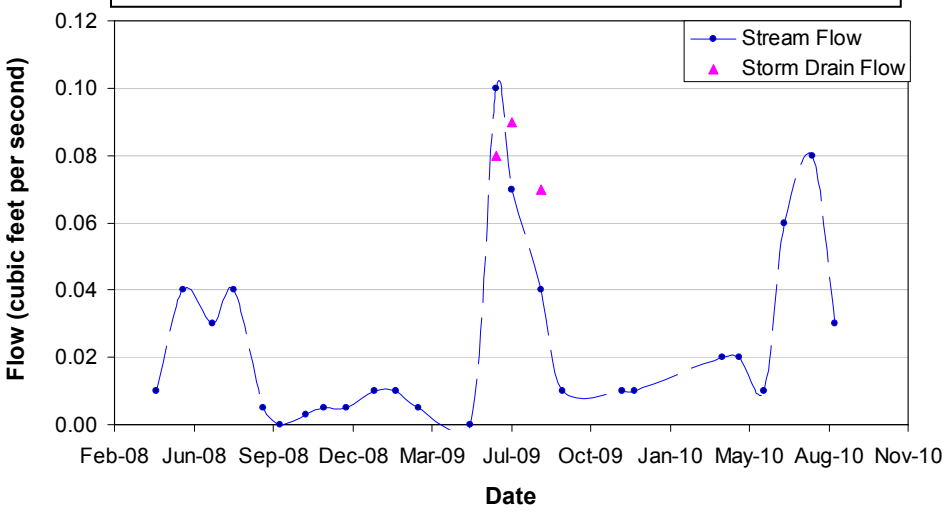
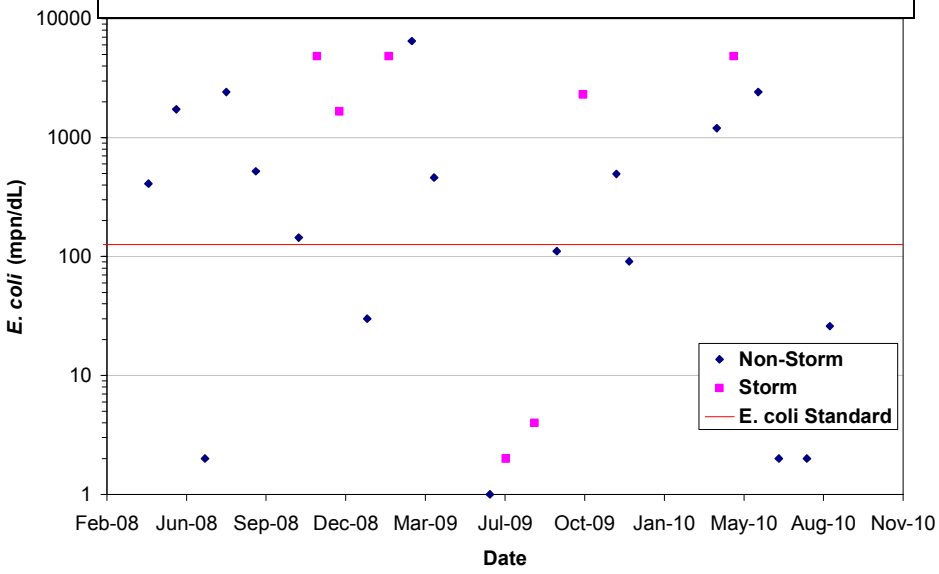


Figure 45. *E. coli* samples collected at Waller Creek at Shipe Park (COA site # 781)



The geometric mean of *E. coli* samples collected under both storm and non-storm flow conditions at Waller Creek at Shipe Park was 175 mpn/100 mL, which exceeds the TCEQ contact recreation limit of 126 mpn/100 mL (**Figure 45**). The geometric mean of *E. coli* samples collected at site # 781 under only baseflow conditions was 141 mpn/100 mL, and was higher than the geometric means for *E. coli* samples collected at 65% of all EII sites. Samples collected during June 2008, and from June through August in 2009 and 2010, represented some of the lowest counts for *E. coli* taken at this site (**Figure 45**). Those sample dates coincide with the period when pool water was being discharged to the stream, and this practice may have chlorinated part of the stream and diluted ambient stream water. If *E. coli* samples collected during the summer months (June through August) are removed from the sample set, then the geometric mean of *E. coli* samples collected at site # 781 under only baseflow conditions would be 837 mpn/100 mL and would be higher than the geometric means for *E. coli* samples collected at 95% of all EII sites.

Pool management practices at Shipe Park during the summer months may mask the magnitude of bacteria contamination problems within this reach.

The mean for ammonia concentrations in samples collected under baseflow conditions at site # 781 was 0.07 mg/L, and ranked higher than the means for ammonia concentrations recorded at 90% of all EII sites (**Figure 46**). The mean for nitrite/nitrate in samples collected under baseflow conditions at site # 781 was 0.75 mg/L, and ranked higher than the means for nitrite / nitrate concentrations recorded at 73% of all EII sites (**Figure 47**). The mean for ortho-phosphate concentrations in samples collected under baseflow conditions at site # 781 was 0.07 mg/L, and ranked higher than the means for ortho-phosphate concentrations recorded at 70% of all EII sites (**Figure 48**).

Field notes indicate that the surface water at site # 781 was clear during baseflow conditions, but even small storm events result in very turbid dark brown water. Milky discharges were occasionally seen downstream of the storm pipe that drains the pool. Odors were reported during several sight visits, including that of decomposed organic material and possibly raw sewage from vagrant latrine sites. A strong odor of chlorine was present at this site during the summer months. Chlorine bleaching was apparent on the substrate downstream of site # 781 during the summer months (algae and invertebrates disappeared).

Access to the stream is available through the pool and park. Although no primary contact recreation was observed, a homeless camp site was present under the Avenue G Bridge during October and September, 2008, and seven individuals were sitting on chairs in the channel on August 27th, 2008.

Figure 46. Ammonia samples collected at Waller Creek at Shipe Park (COA site # 781)

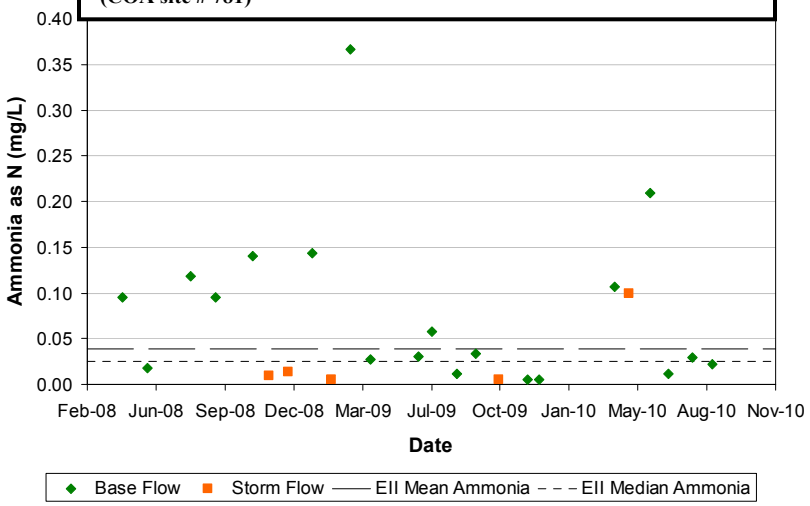


Figure 47. Nitrite / Nitrate samples collected at Waller Creek at Shipe Park (COA site # 781)

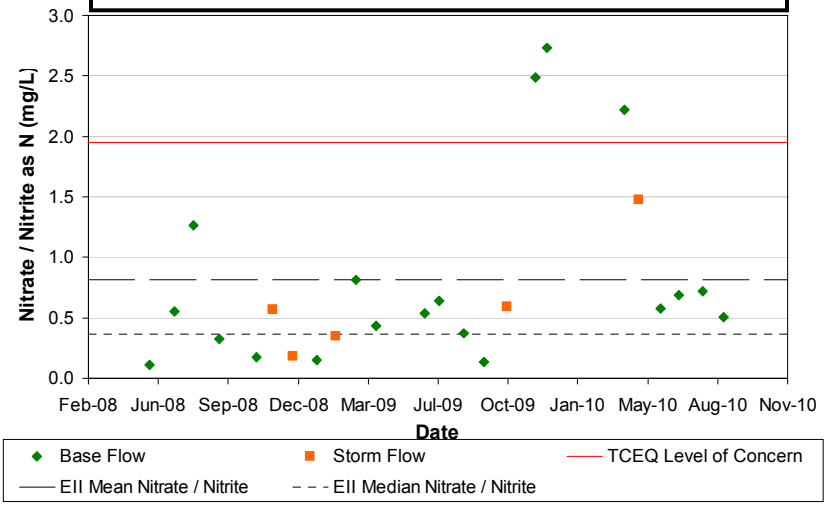
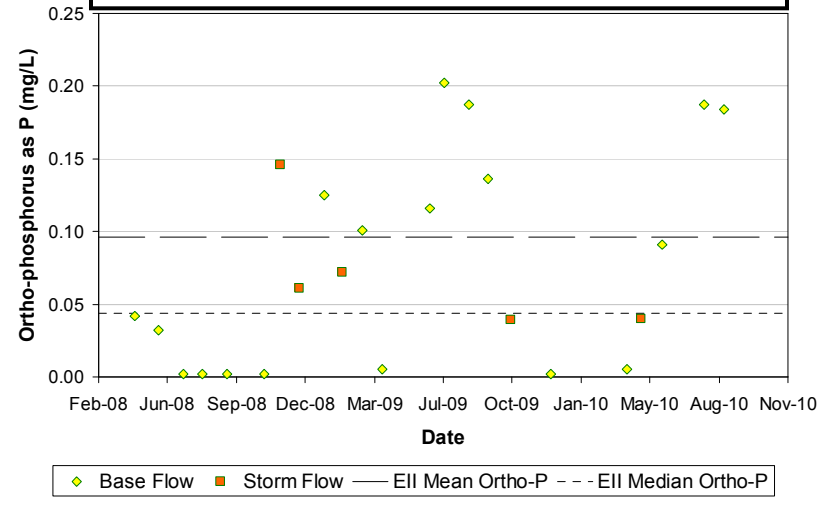


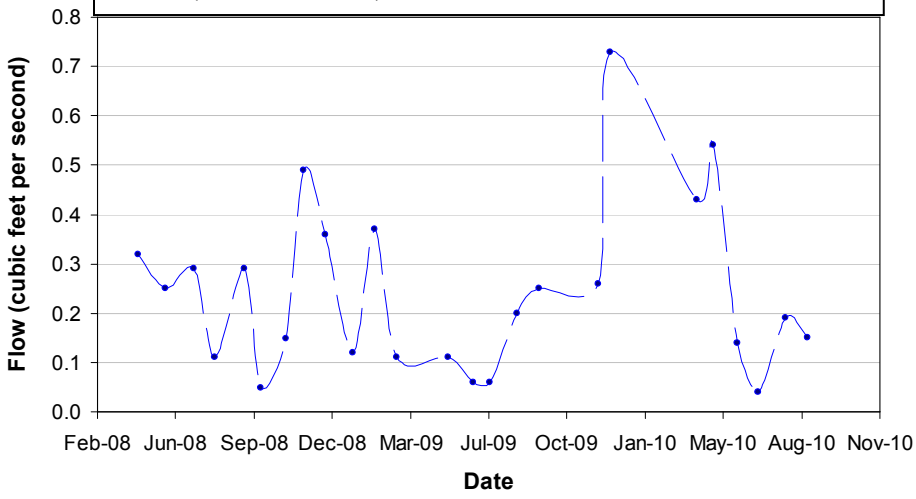
Figure 48. Ortho-phosphate samples collected at Waller Creek at Shipe Park (COA site # 781)



Results for Site # 4349: Waller Creek at 24th Street

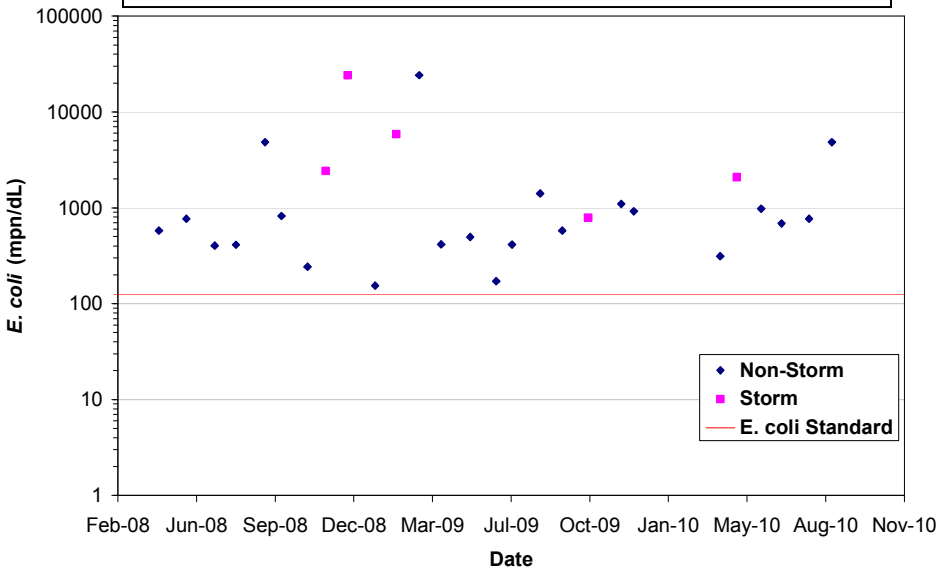
Waller Creek at 24th Street maintains perennial flow (**Figure 49**), and water samples were collected during each of the 27 monitoring events.

Figure 49. Stream discharge recorded at Waller Creek at 24th Street (COA site #4349)



The geometric mean of *E. coli* samples collected under both storm and non-storm flow conditions at Waller Creek at 24th Street was 1014 mpn/100 mL, which exceeds the TCEQ contact recreation limit of 126 mpn/100 mL (**Figure 50**). The geometric mean of *E. coli* samples collected at site # 4349 under only baseflow conditions was 709 mpn/100 mL and was higher than the geometric means for *E. coli* samples collected at 93% of all EII sites.

Figure 50. *E. coli* samples collected at Waller Creek at 24th Street (COA site #4349)



The mean for ammonia concentrations in samples collected under baseflow conditions at site # 4349 was 0.056 mg/L, and ranked higher than the means for ammonia concentrations recorded at 85% of all EII sites (**Figure 51**). The mean for nitrite / nitrate concentrations in samples collected under baseflow conditions at site # 4349 was 0.49 mg/L, and ranked higher than the means for nitrite / nitrate concentrations recorded at 60% of all EII sites (**Figure 52**). The mean for ortho-phosphate concentrations in samples collected under baseflow conditions at site # 4349 was 0.096 mg/L, and ranked higher than the means for ortho-phosphate concentrations recorded at 78% of all EII sites (**Figure 53**).

Field notes indicate that the surface water at site # 4349 was often clear, but tannic in color, with occasional oily patches (from decomposition, not hydrocarbons) and surface scum from pollen and leaves. At other times the water at this site was described as slightly to moderately turbid, and occasionally grayish or brownish in color. Most reports of turbid water were associated with rainfall that occurred zero to four days prior to sampling. Small amounts of foam were occasionally observed on the water surface. A faint odor of sewage was reported on January 14th, 2009.

Recreational uses were not observed during sampling events, but UT students do occasionally come down to this part of the creek (evidenced by sitting benches). Some UT courses use this part of Waller Creek as a site to conduct labs and wading occurs when students collect data from the stream as observed by COA staff .

Figure 51. Ammonia samples collected at Waller Creek at 24th Street (COA Site # 4349)

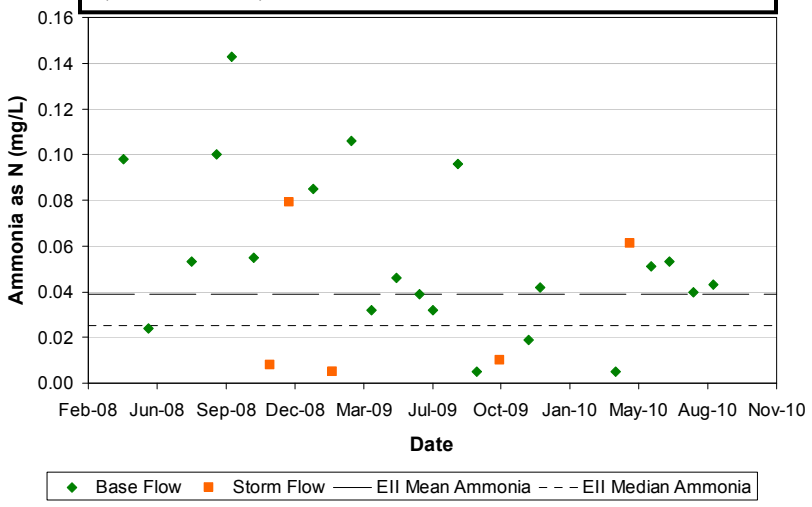


Figure 52. Nitrite / Nitrate samples collected at Waller Creek at 24th Street (COA Site # 4349)

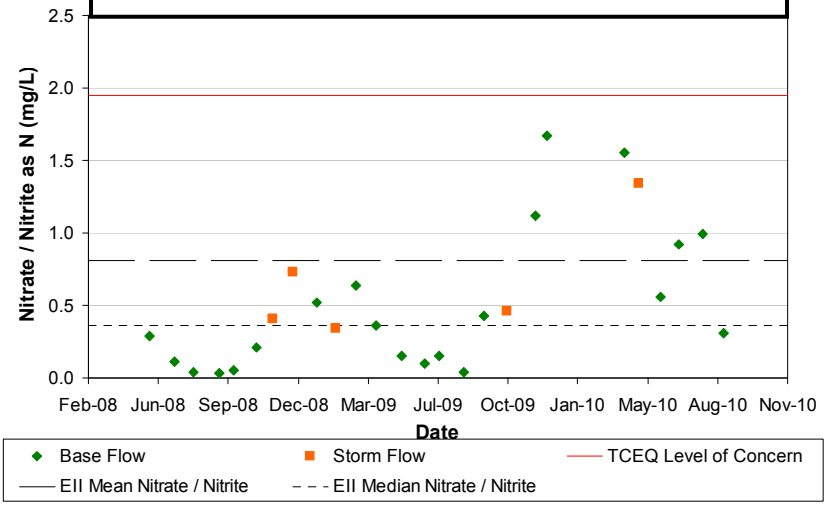
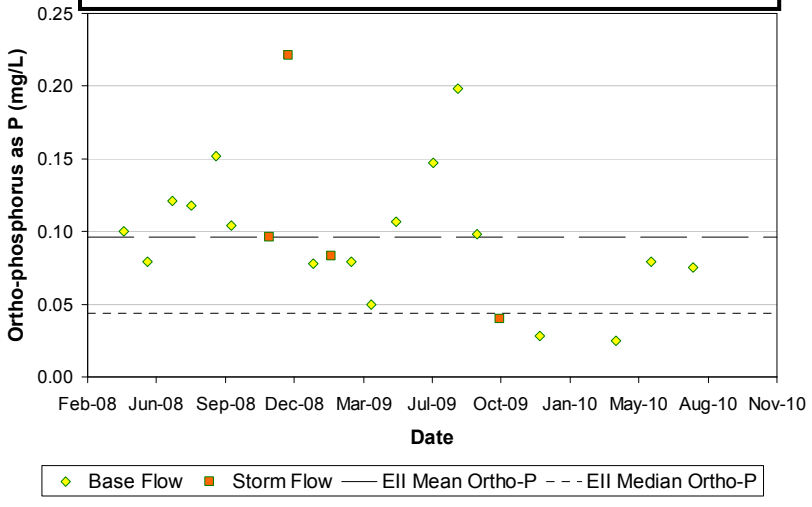


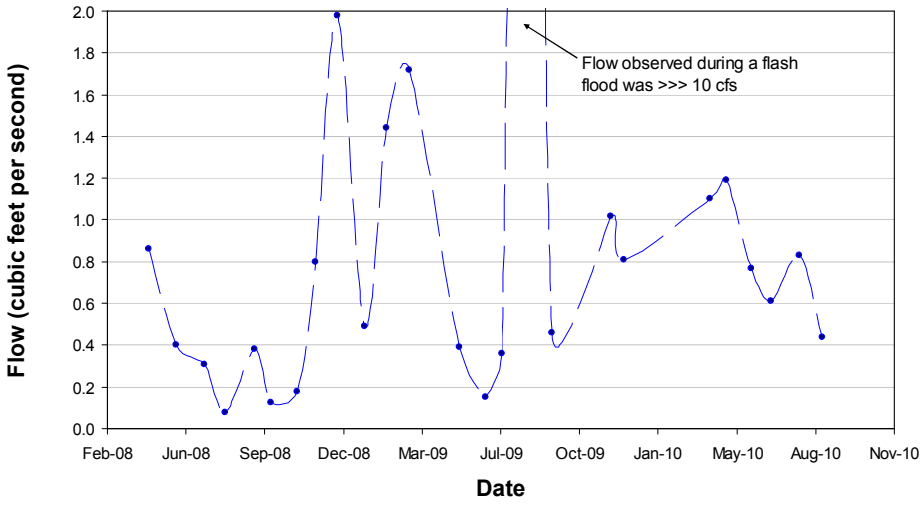
Figure 53. Ortho-phosphate samples collected at Waller Creek at 24th Street (COA Site # 4349)



Results for Site # 485: Waller Creek downstream of 3rd Street

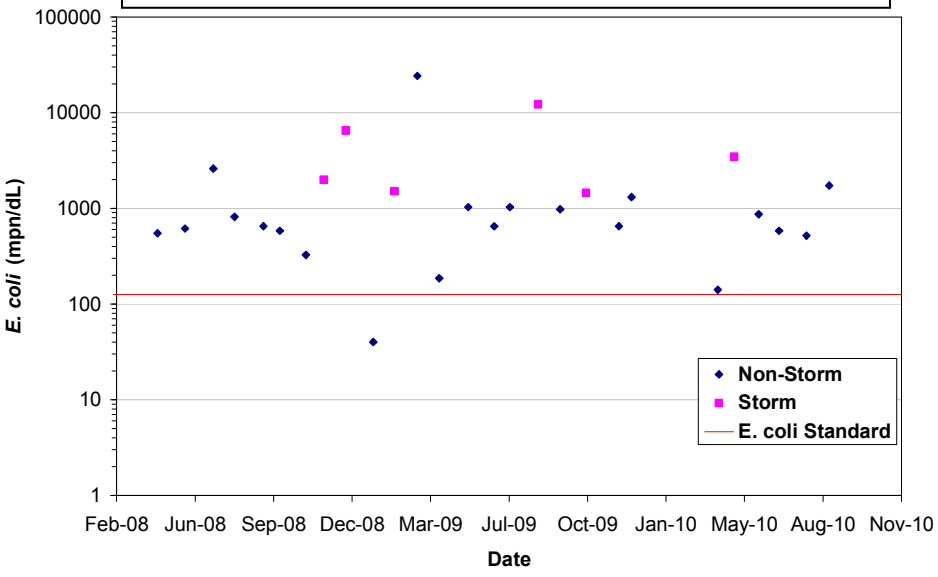
Waller Creek downstream of 3rd Street maintains perennial flow (**Figure 54**), and water samples were collected during each of the 27 monitoring events. High peaks in **Figure 54** demonstrate the flashiness of this stream in response to storm events.

Figure 54. Stream discharge recorded at Waller Creek downstream of 3rd Street (COA site #485)



The geometric mean of *E. coli* samples collected under both storm and non-storm flow conditions at Waller Creek downstream of 3rd Street was 987 mpn/100 mL, which exceeds the TCEQ contact recreation limit of 126 mpn/100 mL (**Figure 55**). The geometric mean of *E. coli* samples collected at site # 485 under only baseflow conditions was 701 mpn/100 mL and was higher than the geometric means for *E. coli* samples collected at 93% of all EII sites.

Figure 55. *E. coli* samples collected at Waller Creek downstream of 3rd Street (COA site #485)



The mean for ammonia concentrations in samples collected under baseflow conditions at site # 485 was 0.07 mg/L, and ranked higher than the means for ammonia concentrations recorded at 90% of all EII sites (**Figure 56**). The mean for nitrite / nitrate concentrations in samples collected under baseflow conditions at site # 485 was 0.62 mg/L, and ranked higher than the means for nitrite / nitrate concentrations recorded at 69% of all EII sites (**Figure 57**). The mean for ortho-phosphate concentrations in samples collected under baseflow conditions at site # 485 was 0.121 mg/L, and ranked higher than the means for ortho-phosphate concentrations recorded at 85% of all EII sites (**Figure 58**).

Field notes indicate that the surface water at site # 485 was normally clear under baseflow conditions, but the water at this site was always turbid after rain, and could remain so with as little as 0.8" of rain, 36 hours prior to a site visit. Surface foam was observed occasionally. Strong odors of urine and feces were normally evident at this site. Latrine sites with rotting food, feces and urine were observed during several

site visits. Large litter, including old mattresses, sleeping bags, bathing supplies and clothing were also often present; and this suggested that the area is frequently used as a campsite by the indigent population living downtown Austin. During storm events the latrine sites were flushed into the creek and most of the litter items described above were probably also contaminated with untreated waste.

Traditional recreation uses were not observed during sampling events, but people were often observed in sleeping bags under the Red River Street Bridge, and the presence of the litter items listed above suggests that significant contact with contaminated water probably occurs at this location. During visits to this area related to other projects COA staff have observed people bathing in this stretch of Waller Creek. The presence of latrines, bathing sites, and camp sites suggests that there may also be a higher risk of disease transmission within this reach of Waller Creek.

Figure 56. Ammonia samples collected at Waller Creek downstream of 3rd Street (COA site #485)

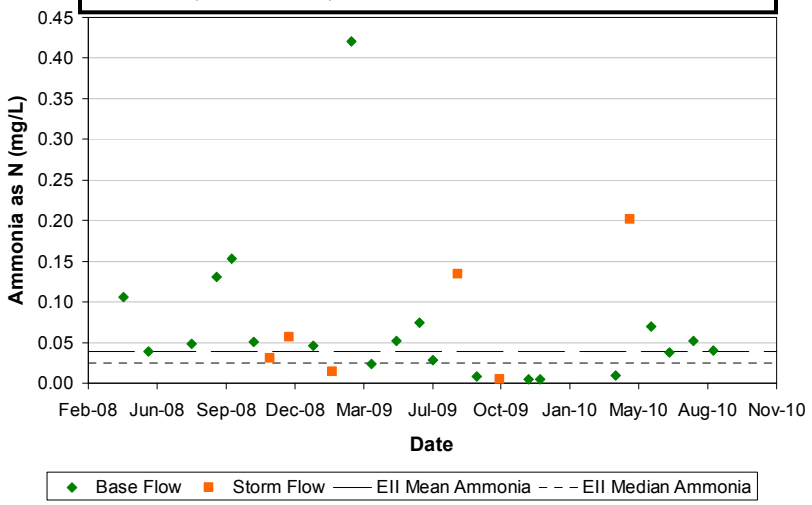


Figure 57. Nitrite / Nitrate samples collected at Waller Creek downstream of 3rd Street (COA site #485)

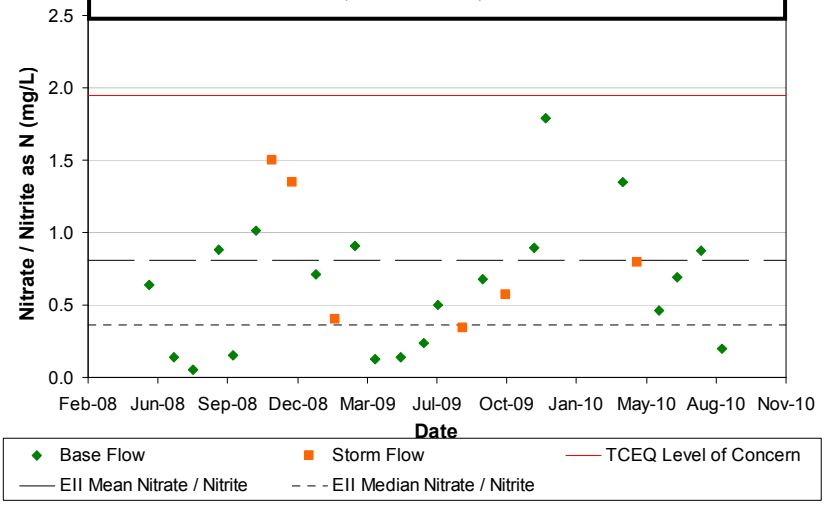
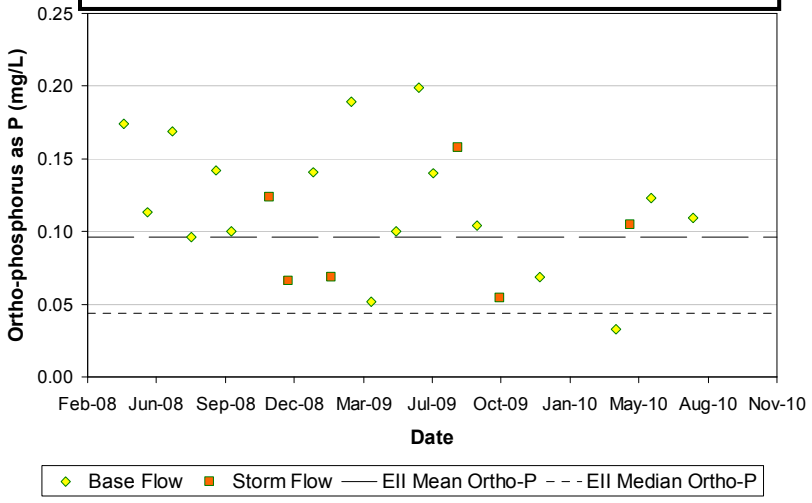


Figure 58. Ortho-phosphate samples collected at Waller Creek downstream of 3rd Street (COA site #485)



Results for Site # 298: Westlake-Davenport Tributary 1 downstream of Westlake Drive

Stream discharge at Westlake-Davenport Tributary 1 downstream of Westlake Drive was typically very low, often less than 0.05 ft^3/s during warmer months, and was probably impacted by drought (**Figure 59**). Higher flows were recorded during cooler months, or in response to rain events. The stream had no flow on August 12th, 2009 (**Figure 59**). Water samples were collected on 21 out of 23 site visits.

Figure 59. Stream discharge recorded at Westlake-Davenport Tributary 1 downstream of Westlake Drive (COA site # 298)

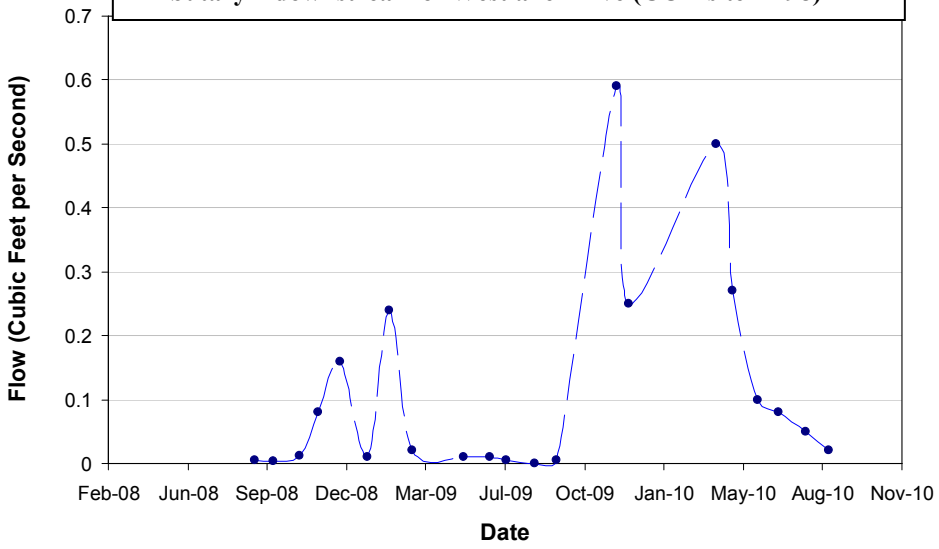
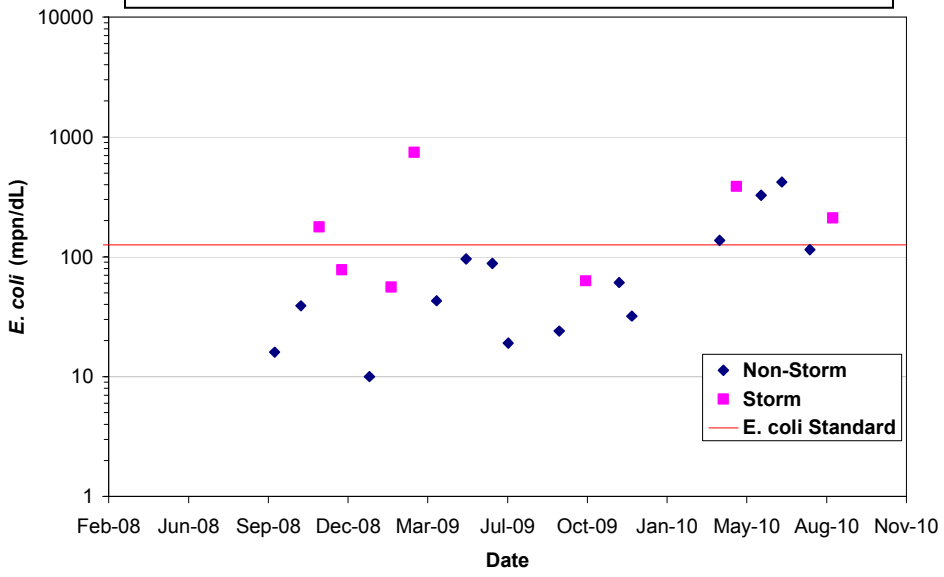


Figure 60. *E. coli* samples collected at Westlake-Davenport Tributary 1 downstream of Westlake Drive (COA site # 298)



The geometric mean of *E. coli* samples collected under both storm and non-storm flow conditions at Westlake-Davenport Tributary 1 downstream of Westlake Drive was 81 mpn/100 mL, which is less than the TCEQ contact recreation limit of 126 mpn/100 mL (**Figure 60**). The geometric mean of *E. coli* samples collected at site # 298 under only baseflow conditions was 49 mpn/100 mL and was lower than the geometric means for *E. coli* samples collected at 74% of all EII sites. A discharge into Westlake-Davenport Tributary 2, which joins Westlake-Davenport Tributary 1 downstream of TMDL monitoring site # 298, was observed on December 10th, 2008. Samples taken from Tributary 2 on that date had *E. coli* counts of > 2420 mpn/100 mL. The COA Spill Response Team investigated and found out that the Austin Country Club Golf Course, which utilized treated effluent water from the Davenport Water Treatment Plant, had opened a release valve to an irrigation system that led to the discharge. Spills Response Team staff instructed the golf course to stop the discharges until the irrigation water was no longer contaminated, and also contacted the treatment plant. The Davenport Treatment Plant was later decommissioned and wastewater from this development was diverted to Austin Water Utility collection system. This spill did not elevate bacteria in Tributary 1 at site # 298. The golf course stopped irrigating using treated effluent water after the decommissioning of the Davenport Plant.

The mean for ammonia concentrations in samples collected under baseflow conditions at site # 298 was 0.015 mg/L, and ranked lower than the means for ammonia concentrations recorded at 86% of all EII sites (**Figure 61**). The mean for nitrite / nitrate concentrations in samples collected under baseflow conditions at site # 298 was 0.73 mg/L, and ranked higher than the means for nitrite / nitrate concentrations recorded at 73% of all EII sites (**Figure 62**). The mean for ortho-phosphate concentrations in samples collected under baseflow conditions at site # 298 was 0.093 mg/L, and ranked higher than the means for ortho-phosphate concentrations recorded at 79% of all EII sites (**Figure 63**).

Field notes indicate that the surface water at site # 298 was almost always clear, and only rarely turbid after storm events. No unusual odors were ever reported at this site. The most notable characteristic of this site was the abundance of filamentous algae present throughout much of the year, and also the vigorous growth of terrestrial and aquatic plants throughout the stream channel, which was apparently frequently mowed (**see Study Site Figures 29-32**). The golf course adjacent to site # 298 exerted a strong influence on the stream at this location, and the abundance of plant and algae growth was likely due to that influence.

This site is within the Austin Country Club Golf Course, and public access is discouraged. Contact recreation activities were not observed.

Figure 61. Ammonia samples collected at Westlake-Davenport Tributary 1 downstream of Westlake Drive (COA site # 298)

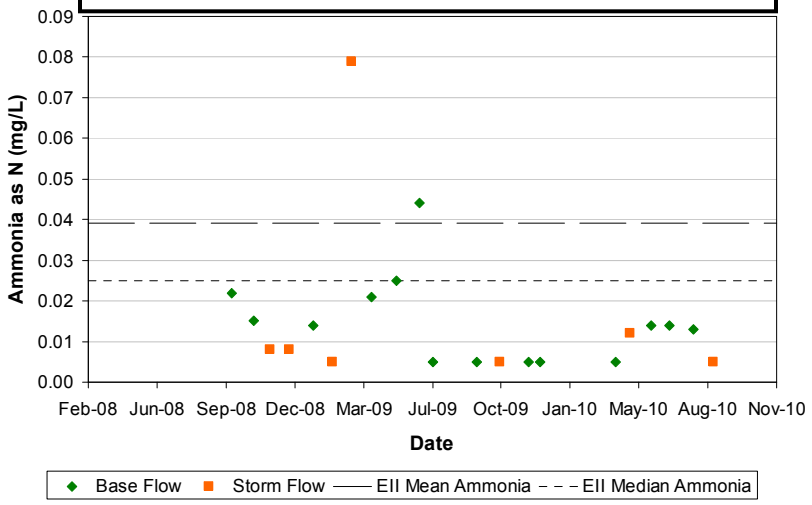


Figure 62. Nitrite / Nitrate samples collected at Westlake-Davenport Tributary 1 downstream of Westlake Drive (COA site # 298)

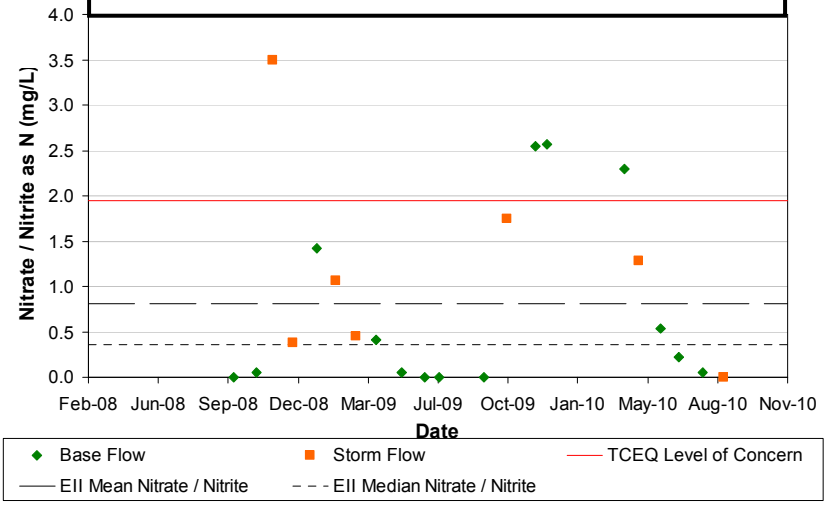
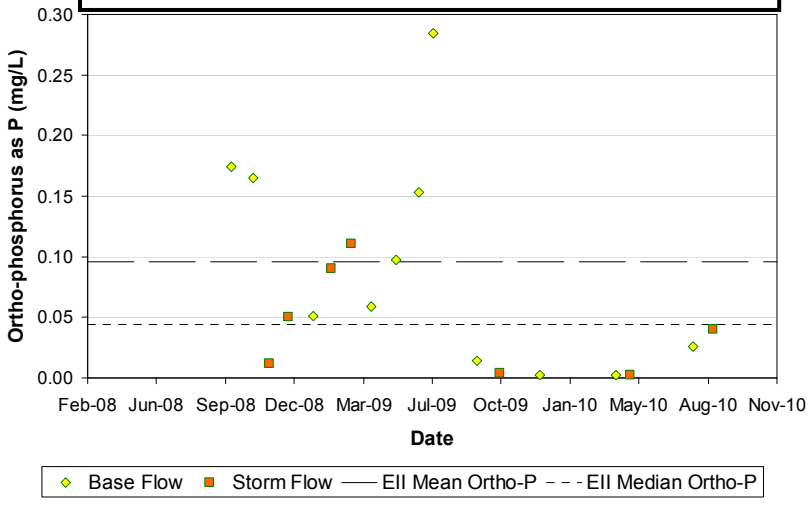


Figure 63. Ortho-phosphate samples collected at Westlake-Davenport Tributary 1 downstream of Westlake Drive (COA site # 298)



Conclusions

All of the seven sites surveyed during this study maintained sufficient flow to assesses contact recreation safety using fecal indicator bacteria, with the exception of Eanes Creek at Rollingwood Drive, where primary contact recreation most likely does not occur. All of the remaining six sites except Westlake-Davenport Tributary 1 yielded *E. coli* geometric means greater than 126 mpn/100 mL based on at least 10 data points distributed over more than a two year period, and thus are not supporting primary contact recreation (**Table 6**). Westlake-Davenport Tributary 1 is currently fully supporting contact recreation. Primary contact recreation is not supported at the Waller Creek, Taylor Slough South or Spicewood Tributary study sites.

Table 6. Summary of geometric means for *E. coli* samples used to determine impairment status of study sites.

COA Site #	Site Name	# *E. coli* samples	*E. coli* geometric mean (mpn/100 mL)
182	Eanes Creek at Rollingwood Drive	n/a	n/a
298	Westlake Davenport Trib 1 D/S Westlake Drive	21	81.3
781	Waller Creek @ Shipe Park	25	175.2
4349	Waller Creek at 24th Street	27	1013.6
485	Waller Creek Below 3rd Street	27	986.5
890	Taylor Slough South Below Reed Park	12	484.6
930	Spicewood Tributary Below Spicewood Spring	27	780.4

Eanes Creek at Rollingwood Drive (COA site # 182) could not be sampled during this study due to a lack of flow. Site visits confirmed that the lower portion of Eanes Creek within the Edwards Aquifer recharge zone boundary is ephemeral and flows only in immediate response to storm events. The historical indicator bacteria counts that resulted in the impairment listing are likely to have been based entirely upon samples collected during storm flow conditions. The impairment listing of this reach of Eanes Creek is not supported because the data are most likely biased to only storm flow conditions. A recreational use attainability assessment (RUAA) should be performed on Eanes Creek because primary contact recreation use of the lower reach of this stream was not supported by this assessment. An RUAA would likely lead to de-listing of Eanes Creek as impaired for contact recreation.

Samples collected at Westlake-Davenport Tributary 1 (COA site # 298) yielded a geometric mean for *E. coli* that was less than 126 mpn/100 mL. This stream segment appears to be fully supporting primary contact recreation. Elevated levels of nutrients recorded at Westlake-Davenport Tributary 1 were more suggestive of nutrient loading from fertilizer application rather than from leaking wastewater infrastructure, potentially due to management practices of the golf course adjacent to the monitoring site. Continued listing of Westlake-Davenport Tributary 1 as impaired for contact recreation is no longer warranted based on these data.

Samples collected at the Waller Creek study sites (COA site #'s 781, 4349 and 485) all yielded geometric means for *E. coli* that were greater than 126 mpn/100 mL. Comparatively lower levels of *E. coli* reported for Waller Creek at Shipe Park (COA site # 781) were likely due to the influence of swimming pool discharges during the summer months. If samples that are influenced by pool management practices are removed from the analysis, then levels for *E. coli* at Waller Creek at Shipe Park are very similar to those reported at the other Waller Creek study sites. Waller Creek mean ammonia levels exceed the 75th percentile of COA Environmental Integrity Index (EII) monitoring locations. Waller Creek mean ortho-phosphate levels are generally similar to ammonia patterns, but show a trend towards increasing levels of ortho-phosphate from upstream to downstream locations. The nutrient data suggest a possibility of water quality impacts due to leaking wastewater infrastructure in the Waller Creek watershed. Water quality

within the Waller Creek watershed may also be impacted by the indigent population living in park areas and in the Austin downtown area. Assuming primary contact recreation, the continued listing of the Waller Creek segments as impaired on the 303(d) list is warranted. A search for leaks in the wastewater infrastructure within the Waller Creek watershed is recommended, and follow-up monitoring may be necessary to determine whether there are additional significant impacts to water quality in Waller Creek.

Samples collected at Taylor Slough South downstream of Reed Park (COA site # 890) yielded a geometric mean for *E. coli* that was greater than 126 mpn/100 mL. Ammonia levels at this site are somewhat elevated, but relatively average compared to other EII monitoring sites. Ortho-phosphate levels are lower than the majority of EII monitoring sites. Nitrite / Nitrate levels at this location are very high compared to other EII monitoring locations, and this may be suggestive of a bacteria contamination source coming from an area outside of the immediate sample location. Primary contact recreation was observed at Taylor Slough South at Reed Park during this survey. Continued listing of this segment as impaired on the 303(d) list is warranted. Potential sources of contamination at this site include leaking wastewater infrastructure, uncollected pet waste and contaminated groundwater emanating from the spring upstream of the monitoring location. The abandoned wastewater mains upstream of the Reed Park monitoring site merit additional investigation by Austin Water Utility staff to confirm that the abandonment was completed successfully. If a source of fecal contamination cannot be readily located, then microbial source tracking may be necessary to differentiate between human versus animal fecal bacteria at this location. Any follow-up monitoring at this site should take into account that flows in Taylor Slough South become subsurface in the vicinity of Reed Park.

Samples collected at Spicewood Tributary to Shoal Creek downstream of Spicewood Spring (COA site # 930) yielded a geometric mean for *E. coli* that was greater than 126 mpn/100 mL. Levels of ammonia and ortho-phosphorus at this site are very low compared to other EII monitoring locations, but levels of nitrite / nitrate are very high and exceed the TCEQ screening level of 1.95 mg/L for nitrate. High levels of nitrate are most likely due to the influence of groundwater discharged from Spicewood Spring upstream of the monitoring location. Fouling of the water and other problems observed by COA staff in the immediate vicinity of the sample site may also point to leaking wastewater infrastructure at this location. Contact recreation was not observed at the Spicewood Tributary during this survey. Contact recreation may occur in parks that are downstream within the Shoal Creek watershed. Assuming primary contact recreation, the continued listing of the Spicewood Tributary to Shoal Creek as impaired on the 303(d) list is warranted. Wastewater infrastructure in the vicinity of site # 930 should be investigated for leaks. Due to the high likelihood that contaminated groundwater is contributing to bacteria and nutrient contamination at this site, source water identification and bacterial monitoring of the springs within this reach are recommended. The source(s) of contamination contributing to impairment of the Spicewood Tributary may also be a factor contributing to the decline of Jollyville Plateau salamanders (*Eurycea tonkawae*) at this location.

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